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SOME ECTOPARASITES OF BATS FROM INDIA

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INTRODUCTION

During the course of an investigation of bats and their distribution in the Bombay State in the years 1947-1949, a number of specimens of bats were found to be heavily infested with ectoparasites. The present study was undertaken in 1951.

A list of external and internal parasites of bats reported upto 1930 has been published in a summary catalogue by Stiles and Nolen (1931). A reference to this list shows that a relatively few species of tropical bat parasites have been carefully studied and this is particularly true in India.

The common external parasites of bats are Diptera Pupipara flies and mites. Considerable work has been done on their systematics and binomics in some parts of the world but very little in India. Scott (1908-1936), Bal & Ahmad (1949) and Jobling (1951) studied a few species of Nycteribiids and Streblids from Indian bats. MacCann (1940) has also referred to a few winged and wingless parasites from *Rousettus leschenaulti*. Nothing is practically known about mites, another important group of parasites found on bats, excepting a few records by Oudemans (1914) and Radford (1936-1953). Kunhikannan (1912), Jordan and Rothschild (1912), Patton (1913) and Mathur (1952) have reported a few batbugs from India. Smit (1954) has recorded a few species of fleas from Pipistrellus and Rousettus groups of bats.

It will thus be seen that this subject has received very little attention so far and hence a preliminary survey of bat parasites from Bombay State was undertaken with a view to studying the extent of parasitic infestation of bats, the systematics and morphology of some of the species.

MATERIAL AND METHODS

The collections of bats for this study were made from Jogeshwari, Kanheri and Elephanta Caves, Tulsi Lake Tunnel, and other places around Bombay, Robber's Cave Mahabaleshwar, Carla Caves Poona, Hubli, Dharwar, Agra Fort (Uttar Pradesh) and Hampi (Mysore State). A specially made iron ring of 1—1½ feet in diameter, with a black mosquito curtain attached, as in ordinary butterfly net, was found most suitable. Flying-foxes and a few other tree-dwelling bats were shot by a small gun. The net was used inside the caves after the colony of bats was disturbed. Electric torches were found convenient for collection inside the caves. The bats collected from the caves were immediately taken to the laboratory in glass jars, for the removal of parasites. As far as possible, the parasites were removed on the spot and then the bats were taken to the laboratory for critical examination in glass jars. Bigger dipterous flies, fleas, bugs and ticks with their larval forms could be easily removed from the fur and wing membrane of bats with the help of fine forceps. The mites and other minute parasites were collected with the help of binocular microscope.

Before the removal of parasites the bats were narcotised or killed by chloroform and the parasites on their body were rendered less active by sprinkling ether and then picked up by means of camel hair or fine needle. The collected material, except the mites, was preserved in 70 per cent alcohol with a little glycerin. The mites were preserved in 85 per cent ethyl alcohol.

Methods of Examination. The smaller specimens were mounted in Berles's fluid for immediate examination. For detailed external study of insects, the internal organs were removed by dissolving in 10 per cent KOH, dehydrated, cleared and mounted in canada balsam. Nycteribiids, Streblids, fleas and bugs were prepared for permanent mount and the method given below is found suitable:—

(1) Bring down the alcohol preserved material to water by passing through descending grades of alcohol, keeping in each grade 5-10 minutes.
(2) Keep the specimen in potassium hydroxide 5 per cent or 10 per cent for2-4 days.
(3) Wash the alkali by three changes of water. (The specimen may be pressed slowly so as to expel the dissolved internal tissues with the help of a fine pointed wooden splinter)
(4) Three changes of glacial acetic acid, keeping each time for 10 minutes.
(5) Stain if necessary, by adding a small drop of 0.5 per cent acid fuchsin to the glacial acetic acid wherein the specimen is kept.
(6) Remove excess of stain by giving 1 or 2 changes of glacial acetic acid.
(7) Clear in carbo-xylol (1 part of carbolic acid and 3 parts of xylol) for 30 minutes.
(8) Mount in canada balsam.

The above method is suitable for insects and flies having hard chitinous plates on their body and is not suitable for mites, as it brings about contraction. Many methods are in use, for the study of mites, but that of Meillon and Lavoipierrie (1944) is easy and suitable, as it requires minimum amount of handling and the specimens remain in expanded condition, with very little distortion.

Technique of Meillon and Lavoipierrie.

(1) Place the specimen in 10 per cent potassium hydroxide over night or over a low flame for an hour. It is not necessary to boil.
(2) Transfer the specimen to lacto-phenol to which a drop or two aqueous acid fuchsin is added. The lacto-phenol neutralises the potassium hydroxide and clears the specimen. The specimen may be left in stain for some days without fear of overstaining. The lacto-phenol is prepared as follows:—

Chloral hydrate	2 parts
Carbolic acid crystals	1 part
Lactic acid..	1 part

(3) Remove the excess of stain with the help of slight heat.
(4) Pick up the stained and cleared specimen by means of a fine needle and remove the lacto-phenol by filter paper (If lacto-phenol is allowed to remain with the specimen, it crystalises in the mounting medium)
(5) Mount the specimen in Ewing's or Berles's fluid.

Recently Baker and Wharton (1952) have evolved a new method for mounting mites where polyvinyl alcohol has been used.

The holotypes of the species described in this paper are in the collection of authors, at Institute of Science, Bombay and the paratypes have been presented to the Zoological survey of India, Calcutta.

THE BAT FAUNA OF BOMBAY STATE

The following list is based on past records and also from the collections made during the course of this study.

MEGACHIROPTERA

Pteropidae

(1) *Pteropus giganteus giganteus* Brun., 1827.
Distribution:—Widely distributed all over India, Ceylon and Burma.

(2) *Rousettus leschenaulti* Desm.
This is a widely distributed species being reported from Western Ghats, Rajputana, Nepal upto as far as Coorg.

(3) *Cynopterus sphinx sphinx*, Gray.
It is widely distributed extending as far as Sikkim, Shan States and Ceylon.

MICROCHIROPTERA

Rhinopomatidae

(4) *Rhinopoma hardwicki*
Bombay (Gadag), Agra Fort, Hampi (Mysore State).

Rhinolophidae

(5) *Rhinolophus rouxi* Temn.
The distribution is all over India and is found in large colonies along the wet regions of the Western Ghats, Bengal, Nilgiris, Pondichery, Kanara, Sikkim and Ceylon.

(6) *Rhinolophus luctus beddomi* Besch.
Recorded from Kanara, Coorg, Hyderabad and Ceylon.

(7) *Hipposideros bicolor fulvus* Temn.
All over India, particularly found in Dharwar, Madras, Kanara, Western Ghats, Bengal and Cutch.

(8) *Hipposideros speoris* Schneid.
All over India, Ceylon, particularly along the Western Ghats.

(9) *Hipposideros brachyotus* Dobson.
Central India. Also recorded from Kanara and Bengal, but not very common.

(10) *Hipposideros lankadiva* Kelaart.
Found in Indian main land, Kanara, Mysore, Central Province, Ceylon.

Megadermatidae

(11) *Lyroderma lyra* Geoff.
Type locality. "East coast of Madras."
It has been found in Bombay (Kanheri and Elephanta Caves) and Central India.

(12) *Megaderma trifolium* Geoff.
Kanheri Caves, Kanara, Mysore and Ceylon.

Embollonuridae

(13) *Taphozous longimanus* Hardwick
Type locality—Calcutta. It has been recorded from Bombay, Dharwar, Central India and Western Ghats.

(14) *Taphozous melanopogon*.
Well distributed all over India.

Vespertilionidae

(15) *Pipistrellus ceylonicus chrysothrix*.
Recorded all over India.

(16) *Pipistrellus coromendra* Grey.
Widely distributed in India.

(17) *Pipistrellus mimus mimus* Wroughton, 1899
Type locality:—Surat, Poona, Bombay and many other places.

(18) *Hesperoptenus tickelli* Blyth, 1857.
Type locality:—Chaibassa (Central India). Also recorded from Bombay, Bengal & Madras.

(19) *Pipistrellus affinis* Dobson
From Upper Burma. Also recorded from Kurla (Bombay).

(20) *Scotophilus kuhli*, Leach, 1822.
Common practically all over India, Malaya and Siam.

(21) *Scotophilus wronghtoni* Thomas, 1897.
Type locality:—Surat. Also from Bombay, Central Provinces, Coorg, Mysore and Bengal.

(22) *Kervivoula picta* Pallus, 1767.
Type locality: Indian Peninsula and also from Dharwar and Borivli.

(23) *Miniopterus fuliginosus* Hodgson, 1835.
Western Ghats (Mahabaleshwar), Kumaon, Mount Popa and Upper Burma.

All the bats recorded so far are confined to Oriental and Indo-Malayan Regions and are found as far north as upto the Himalayas. The Palaearctic species of the genera *Pipistrellus*, *Myotis*, *Eptesicus*, *Nyctalus*, *Otonycteris* are only confined to that region and a few of them are recorded from the Himalayan Range including Kashmir. The common flying-fox, i. e. *Pteropus giganteus giganteus* occurs all over India, while some of the species of bats like *Scotophilus* and *Kervivoula* are known only from a few places of Bombay State and Central India.

Bats are known to migrate from one place to another widely separated region. This perhaps provides the clue to the fact that the parasites of bats are so widely distributed. The distribution of Bombay forms of bats is interesting and peculiar owing to the extremes in rainfall experienced in different districts which chiefly govern the range of these species.

DIPTERA PUPIPARA

A. Family Nycteribiidae Westwood, 1840

The early literature on Nycteribiidae is complicated, due to the fact that the authors used to call every parasite of bat a "vespertilionis." Lastreille (1796) erected the genus *Nycteribia* for an insect but gave an acarid as type species. In 1805 Lastreille corrected his mistake and redefined *Nycteribia*, with a type species *Nycteribia vespertilionis*. Westwood (1835) recognised five European species under this genus. Later in 1901, Speiser divided the genus *Nycteribia* into three subgenera—*Acrocholidia*, *Styliäia* and *Listropodia*, keeping the genus *Listropodia* a synonym of *Nycteribia*. He also erected other genera *Penicillidia*, *Eucampsipoda* and *Archinycteribia* for certain species formerly placed by Kolenati (1856) under the genus *Nycteribia*. Scott (1917) erected two more genera *Tripselia* and *Eremoctenia* for some species of *Cyclopodia* and *Nycteribia*.

Musgrave (1925) discussed the subgeneric names and concluded that *Acrocholidia* should be considered as a synonym of *Nycteribia* instead of *Listropodia.* But the present day workers of Nycteribiids do not agree with Musgrave (1925). In view of this the old division of the genus *Nycteribia* has been retained in this paper.

i. GENERAL MORPHOLOGY

Head : In some species of Nycteribiids the head is broadly rounded and in others more or less compressed. In *Cyclopodia* it is flattened dorso-ventrally and in other genera compressed laterally. The palps in *Nycteribia* and *Basilia* are finger-shaped and flattened dorso-ventrally. In *Penicillida* they are thick and bear numerous strong setae. In *Eucampsipoda* they are thick at the base and thin distally, bearing a few strong setae. In all these Nycteribiids the palps bear distally a very long seta, nearly twice as long as the head. The labellum may be long or short than the theca and it is usually long in *Penicillidia* and *Basilia* and short in the remaining genera.

Thorax: It is always dorso-ventrally compressed with the margins bent upwards and more pointed anteriorly than posteriorly. In some species it is wider than long, while in others it is longer than broad. The dorsal surface of the thorax consists of notopleural sutures running laterally, ending in coxa ii. The area between notopleural sutures represents the mesonotum and the anterior part of the mesonotum, bearing head and forelimb as prothorax. The area lateral to the notopleural sutures represents the pleurae. The mesopleural suture in different species bears a varying number of setae and in some the setae may be absent as in *Penicillidia jenynsi* var. *indica.* The halteres lie in a deep groove at the sides of the notopleural sutures near the posterior margin of the thorax. In *Cyclopodia* this groove is covered by a flap, which may be absent or rudimentary in others.

The ventral surface bears a median sternal suture and the sutures between the meso-and metasternum joining anteriorly the median sternal suture. In some species the sternal suture may be clear and in others indistinct. The whole surface is bent antero-posteriorly as in *Penicillidia jenynsi* var. *indica* or only curved dorsoid anterior to the sutures, as in most of the other species. Ventrally the thorax is covered with short setae but those on the hind margin are characteristic, regarding the length and position. In some, the thoracic teeth are blunt and a little apart from each other, whereas in a few instances, the teeth of the ctenidium may be small, triangular and widely separated from others. The thoracic ctenidia are completely absent in *Archinycteribia.*

The legs are comparatively stronger and well developed for clinging to the host and to move freely in the fur of the host. The presence of tibial rings has been used as a diagnostic character of the different genera. In *Nycteribia, Basilia* and *Penicillidia* the tibial rings are absent and in their place there are 3 rows of strong spines. In some genera, the tibial rings are two as in *Eucampsipoda* and three as in *Cyclopodia* and *Tripselia.*

Abdomen : Six of the abdominal segments are clearly visible in Nycteribiidae. Some of these abdominal segments are usually fused into broad plates or into a connecting membrane in the female, while in male the primitive segmentation is still preserved to a much higher degree. Dorsally the tergites 1-6 are usually distinct and the 7th with other tergites is included in the anal segment. In *Eucampsipoda* and *Cyclopodia* the tergites 1 and 2 are fused but in other genera they are separate. Ventrally the abdominal ctenidium is a fused plate of sternites 1 and 2. In *Archinycteribia* and *Eremoctenia* the ctenidium bears long bristles instead of teeth. The post-spiracular sclerite is of generic value. In *Eucampsipoda* it is rather broad without or with only one seta. In *Nycteribia, Basilia* and *Tripselia* it is short, narrow bearing a few short hairs towards the sternites, while in *Paracyclopodia* it is broad and triangular, with 2-4 hairs. In *Tripselia* post-spiracular sclerite is crescent-shaped with a few short hairs on the convex side and in *cyclopodia* it is elongated without any hairs. It is absent in *Penicillidia.*

Genitalia : Very little work has so far been done on genitalia of these Nycteribiids except some superficial observations on aedeagus, parameres and claspers of a few scattered species (Karaman 1948). Recently Theodor and Moscona (1954) have studied in detail the male and female genitalia of the Nycteribiids of Palaearctic Region.

Male genitalia.—The aedeagus in these Nycteribiids, is in the form of two lateral plates fused ventrally and covered with a membrane dorsally. Posteriorly, it articulates with the flattened apodeme which is sometimes fused with the aedeagus. The phallobase in which the aedeagus is placed bears a pair of parameres at its distal extremity. These parameres form a sheath for the aedeagus when at rest. The phallobase is strengthened by an additional piece, which is interpreted as the 7th, 8th and 9th sternites. There is a pair of strong claspers, with long and short hairs, on either side of the depression, where the male genitalia is placed. In the genus *Eucampsipoda* the genital apparatus is much more complicated. In this, the aedeagus is a wide tube with a dorsal thin wall, the anterior part of which bearing teeth is invaginated. The parameres are reduced to two triangular plates on the aedeagus. During copulation the invaginated membrane of the aedeagus forms a large bulbus endophallus in the centre of which lies the gonopore. Genital apparatus somewhat of a similar nature is also found in some species of *Cyclopodia.* The shape of the aedeagus and parameres vary in different genera and species and it is of great taxonomic value.

Female genitalia.—This consists of two plates, dorsal and ventral. The dorsal plate is usually triangular, bearing short setae along its posterior border. The ventral plate, representing the sternite 7 or 8, may be present or rudimentary. These plates which vary in different genera and species of Nycteribiids over the genital opening.

ii. KEY TO GENERA

1.	Thoracic and abdominal ctenidia present	 2
	Thoracic ctenidia absent and abdominal ctenidium present	*Archinycteribic* Speiser, 1900.
	Thoracic and abdominal ctenidia absent	*Eremoctenia* Scott, 1917.
2.	Tibia with 2 or 3 rings. Anterior coxa usually longer than broad ...	 3
	Tibia without rings but with 3 rows of spines. Anterior coxa seldom longer than broad	 5
3.	Tibia with 2 rings	*Eucampsipodc* Kolenati, 1857
	Tibia with 3 rings	 4
4.	Head with eyes	*Cyclopodia* Kolenati, 1863
	Head without eyes	*Tripselia* Scott, 1917
5.	Head without eyes	*Nycterbia* Latreille, 1796.
	Head with eyes	 6
6.	Eyes composed of 1 ocellus	*Penicillidia* Kolenati, 1863.
	Eyes composed of 2 ocelli	*Basilia* Mir. Ribeiro, 1903.

iii. SYSTEMATIC PART

Genus **Nycteribia** Lastreille, 1796

This genus is recognized by the absence of tibial rings and eyes. The genus has been divided into three subgenera by Speiser (1901) viz. *Acrocholidia* Kolenati, 1857, *Stylidia* (=*Celeripes*) Montagu, 1808 and *Listropodia* (=*Nycteribia*) Kolenati, 1856. The subgenus *Stylidia* is based on the anal segment with a pair of anal lobes. The subgenus *Acrocholidia* is characterised by a more or less tapering anal segment without lobes, while the subgenus *Listropodia* differs from these two in having the tibia expanded and shovel-shaped.

1. **Nycteribia (Acrocholidia) phillipsi** Scott, 1925

(Figs. 1—10)

Scott (1925) described the female of this species from specimens obtained from *Rhinolophus rouxi* at Ceylon. Subsequently, in 1936, he briefly described the male from two specimens, showing Laboulbenous growth on the abdomen from the same host and place. In the course of investigation, the authors came across good many specimens of this species, without Laboulbenous fungus on the abdomen. The material before me differs in chaetotaxy and other anatomical features from the Ceylonese material. This is the first record of this species from India.

Length : 2-2.4 mm. *Colour*:—Light yellowish-brown.

Head Rather long, moderately compressed laterally, with the anterior

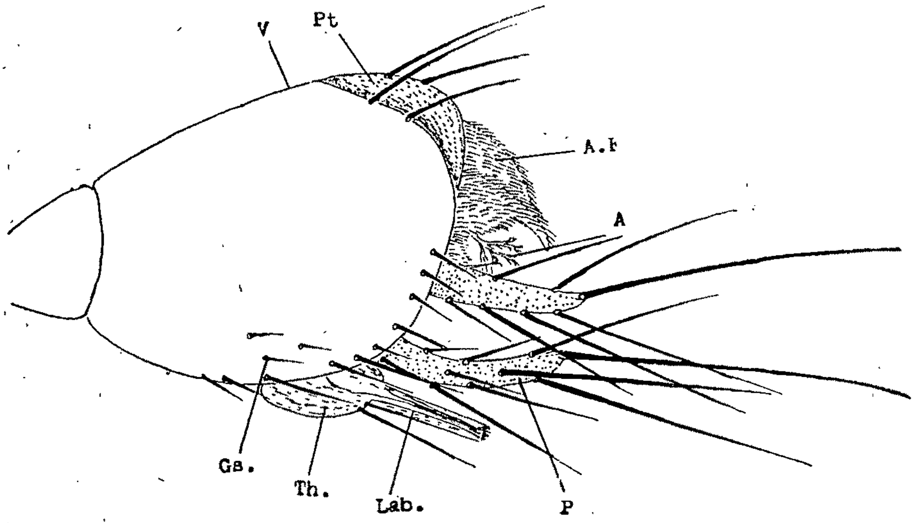


FIG. 1. *Nycteribia phillipsi.* Lateral view of head.

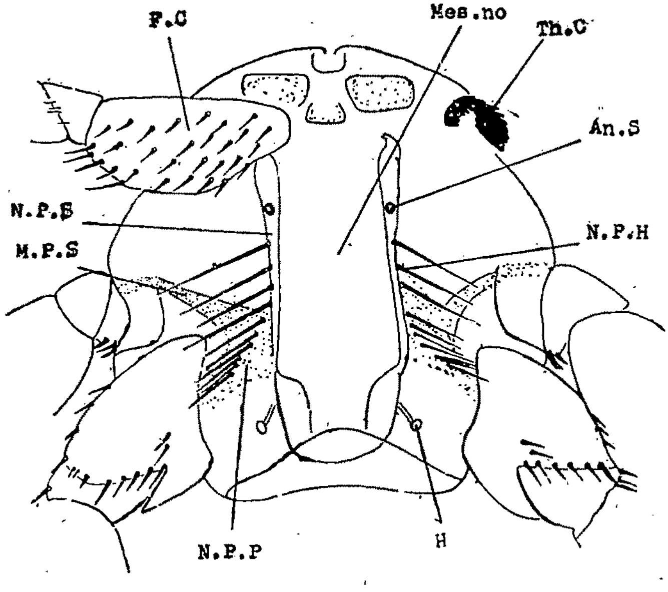


FIG. 2. *Nycteribia phillipsi.* Dorsal view of thorax.

margin, bearing 4-6 long setae on the the vertex. A row of short setae along the anterior margin of cheeks. Genae with 3-4 short setae. Eyes absent. Labella longer than theca.

Thorax : As long as broad. Length 0.9 mm. Median sternal suture flattened in the middle and clear posteriorly. Oblique sutures well marked. Ctenidium with about 20 long and pointed spines. A row of 10-12 notopleural hairs situated just posterior to the anterior spiracles. Tibiae slender, with 3 rows of long setae in the distal half ventrally.

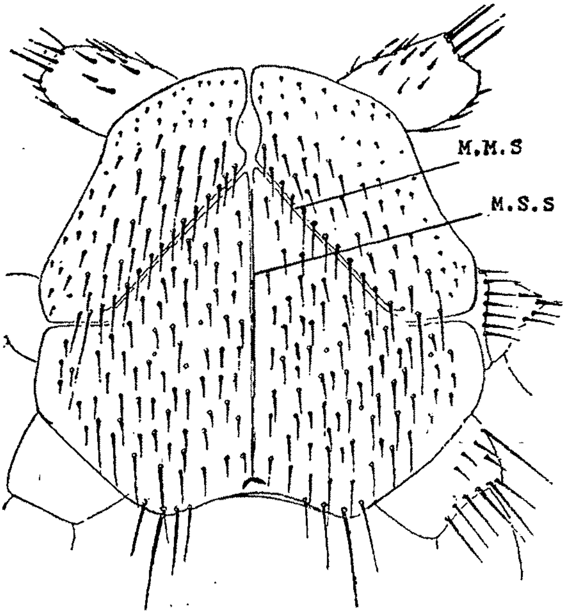
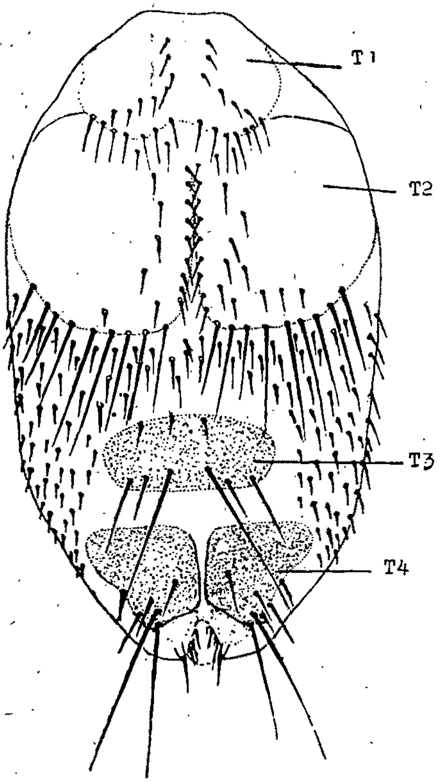


FIG. 3. *Nycteribia phillipsi* Ventral. view of thorax.

Abdomen in female : Tergite 1 roughly trapezoidal, with slightly concave posterior margin bearing short hairs and a few short ones along the middle of the surface. Tergite 2 broad, completely divided into two halves along the median longitudinal line. A row of long setae at the flattened posterior margin. Surface with a few short hairs along the median longitudinal line and a little longer ones lateral to these. Tergite 3 consists of a chitinous plate, twice broader than long bearing a median longitudinal faint line. Its posterior margin bears 6 long setae, of these two in the middle longer still. Two or three short hairs towards the anterior border of this sclerite in Ceylonese specimens; but the surface smooth in the local form. Lateral to this sclerite the connexivum studded with short and stumpy spines. Anteriorly, the connexivum with a moderately long spines between the tergites 2 and 3. Tergite 4 conical, bearing two plates separated from each other by a narrow gap. Surface of each plate smooth except a few short setae in the posterior half region and the corners with 1-2 long setae. Pleurae with closely placed short spines.

Sternite 1+2 small, narrow, with the hind-most setae rather longer than usual and the teeth of the ctenidium close-set, numbering about 50. Sternites 3 and 4 with a row of moderately long setae at the posterior margin. Three to four rows of short setae on sternite 3 and one row on sternite 4 close to the hind margin. Sternites 5 and 6 divided into two narrow plates, each with a convex anterior border and a straight posterior border bearing a few moderately long setae and the surface with scattered short hairs close to hind border. Sternite 7 subtriangular, with angles rounded and the base forming the hind margin. Its pale yellowish-brown chitin, divided into two halves, by a faint median longitudinal thinning. Six to seven long setae with a short break in the middle at its posterior border and the surface with a row of short setae, close to the hind border. Genital plate (Fig. 6) single, smooth, longer than broad, with 2 short hairs at the sides of the convex hind margin.



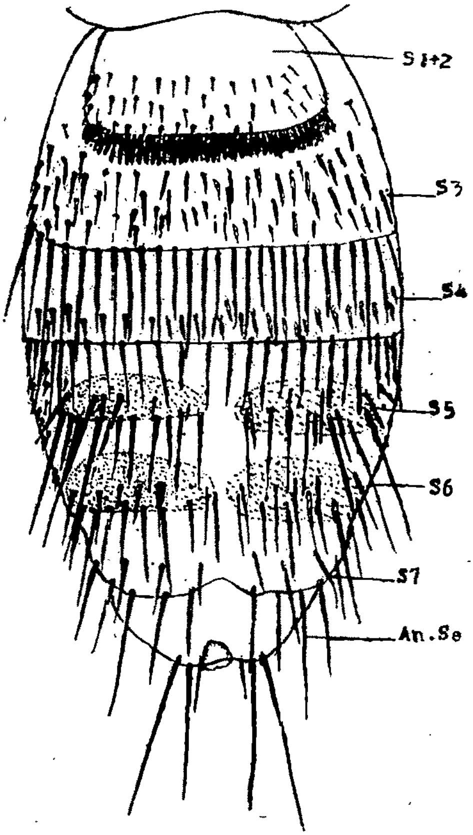


FIG. 5

FIG. 4. *Nycteribia phillipsi.* Dorsal view of feamle abdomen.

FIG. 5. *Nycteribia phillipsi.* Ventral view of female abdomen.

Abdomen in male: Tergite 1 roughly rectangular, with two posterior lobes having a row of short setae. Post-spiracular sclerite (Fig. 7) curved with one end pointed than the other, having 3 long setae, on the convex side. Tergite

2 broad, with a median longitudinal thinning, bearing a group of short hairs in the middle of the surface. A row of uniformly long setae at the posterior margin. Tergites 3-6 narrow, slightly convex posteriorly, with a group of scattered short hairs in the middle of tergites 3 and 4. Tergites 5 and 6 smooth. The hind border of these tergites bears a row of long, spaced-out setae, of which two in the middle are longer still. Anal segment conical, smooth, except for a transverse row of 2-4 short setae, near the hind border and a few longer, stouter ones posteriorly.

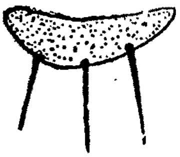


FIG. 7

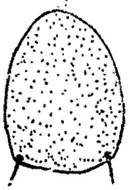


FIG. 6

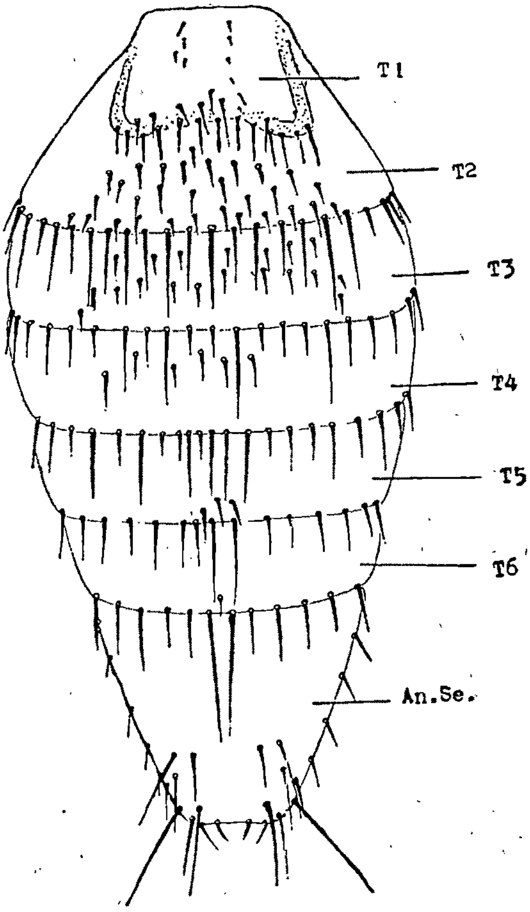


FIG. 8

FIG. 6. *Nycteribia phillipsi.* Genital plate. FIG. 7. Post-spiracular sclerite.
FIG. 8. *Nycteribia phillipsi.* Dorsal view of male abdomen.

Sternites 1+2 rectangular, with the teeth and hairs as in female. Sternite 3 narrow, with a row of long setae at the posterior border and the surface covered with short hairs. Sternite 4 smooth, except two irregular rows of short hairs near the posterior border bearing a row of uniform long setae. Sternite

5 longer than the preceding one and slightly convex posteriorly. A row of setae similar to that found on sternite 4 at the posterior border bearing another irregular row of a little shorter setae anteriorly. Besides, a group of 8-10 peglike spines in the middle of the hind border. Anal segment with a lateral median bulge, covered with hairs.

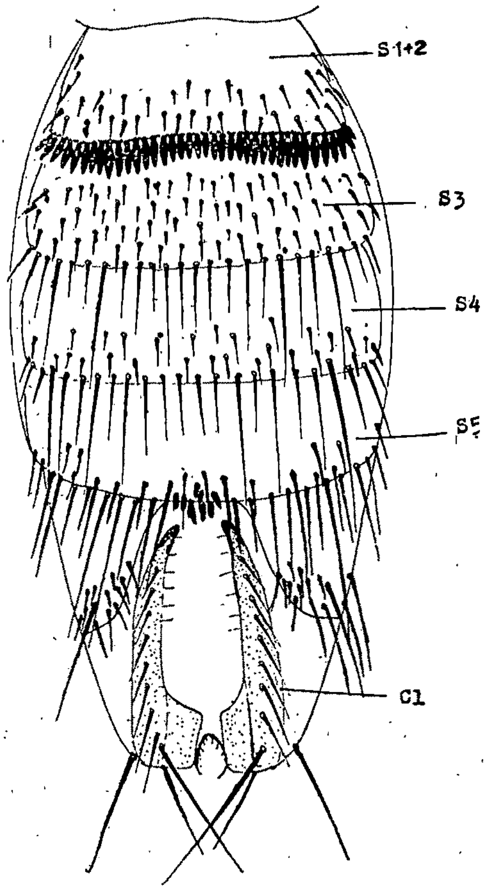


Fig. 9

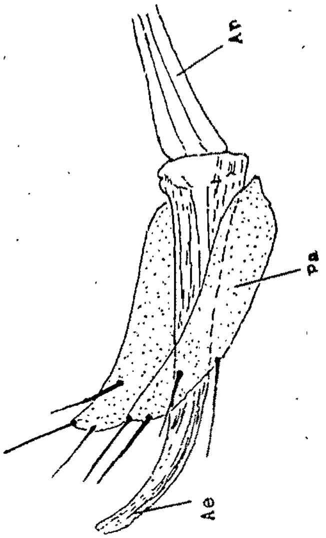


Fig. 10

Fig. 9. *Nycteribia phillipsi*. Ventral view of male abdomen.
Fig. 10. *Nycteribia phillipsi*. Male genitalia. (Basal arc and claspers not shown)

Genitalia (Fig. 10) : Basal arc pigmented, broadly rounded, with a short tip. Claspers with a long seta near its base, a row of moderately long setae on the outer margin and a few short ones on the inner margin. Aedeagus long, curved, with a rounded tip. Apodeme broad, a little longer than the aedeagus and winged at its tip. Parameres broad, shorter than aedeagus, with 3-5 long and slender hairs on the distal half. Phallobase strongly arched, with 4 short hairs, between the base and the basal arc.

Host.—30 females and 24 males from *Rhinolophus rouxi*, Tulsi Lake Tunnel, Bombay, June 1953.

From the above description it is evident that the Indian material differs mainly from the Ceylonese specimens by the following characters:—

(a) The transversely elongated chitinous plate behind the tergite 2 in female shows a faint median longitudinal thinning and is studded with 2-3 fine setae, in the middle near the anterior border, while the specimens from Ceylon are without setae.

(b) In male, sternite 4 has the hind margin acruate, bearing a group of 10-12 black, thorn-like spines instead of 20, as in Ceylonese material.

2. **Nycteribia (Listropodia) allotopa** Speiser, 1901 (Figs. 11-20)

Scott (1908) described this species for the first time under the name *Nycteribia insolita* from *Miniopterus fuliginosus* at Formosa. Later, in 1914 and

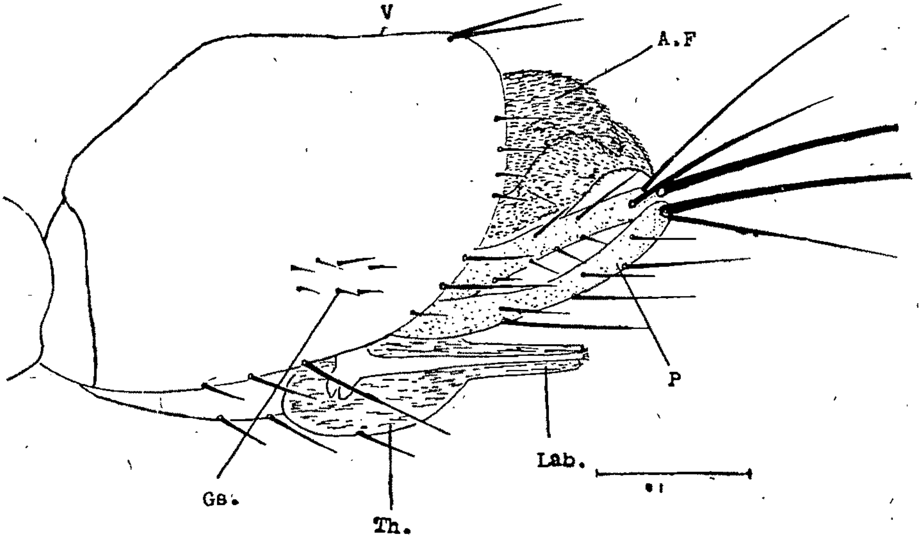


FIG. 11. *Nycteribia allotopa*. Lateral view of head.

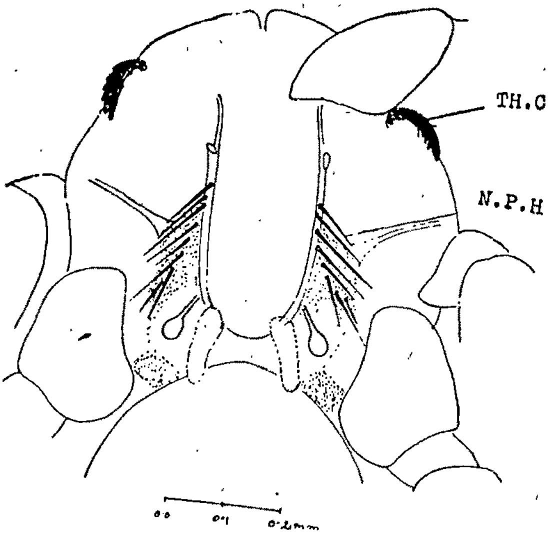


FIG. 12. *Nycteribia allotopa*. Dorsal view of thorax.

1925, he pointed out that the Indo-ceylonese material differs from the Formosan specimens particularly in having tergite 2 of female devoid of setae and tergite 4 of male, with a few scattered setae, while there are none in the Formosan material. Specimens before me differ specially in the number and arrangement of bristles on the abdomen.

Length 2.2-2.4 mm. in both sexes.

Head: Partly membranous anteriorly and moderately compressed laterally. Ptilinum small and inconspicuous. Vertex more or less straight, with a pair of long setae on the anterior margin. A row of short setae, along the anterior border of cheeks and a longer one, above the theca. Genae with 6-7 short hairs. Labella shorter than theca.

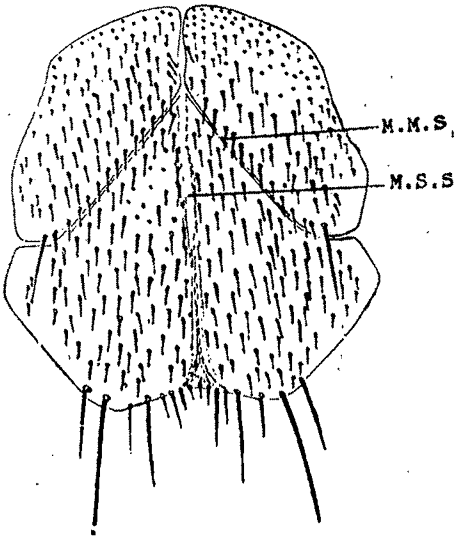


FIG. 13. *Nycteribia allotopa.* Ventral view of thorax.

Thorax: As long as broad, measuring 0.7 mm. Ctenidium with about 15 pointed teeth. Median sternal suture widened in the middle, faint and narrow behind. Meso-and metasternal sutures faint and bordered anteriorly with a row of slightly longer setae. Rest of the surface of the thorax uniformly studded with short hairs. A row of 8-9 notopleural hairs, situated a short distance, behind the anterior spiracles. Halteres with a large knob and exposed. Legs broad and laterally compressed. Coxa i short and covered with fine hairs on the dorsal surface. Femora covered with a few short hairs dorsally and bare ventrally. Tibiae much expanded, nearly 1½ times broader than long, with 3 rows of transverse setae distally, on the ventral surface.

Abdomen in female: Tergite 1 small, rectangular, with a few short hairs on the hind margin and the disc. Tergite 2 smooth, its hind border broad, bearing 10-12 long setae, with 1-2 short ones interspersed between the long setae. The large connexivum, behind tergite 2, consists of 3 segments fused together and studded with a few scattered spine-like setae, longer posteriorly. Tergite 6 a transverse sclerite, situated behind the connexivum, elongated, crescent-shaped, with its hind border slightly concave, bearing 10-12 setae, longer at the sides. Its surface with 4 long setae across the disc, the middle pair longer than the lateral ones, extending up to the posterior border of the anal segment. Anal segment separated from the rest of the abdomen, by a well developed cons-

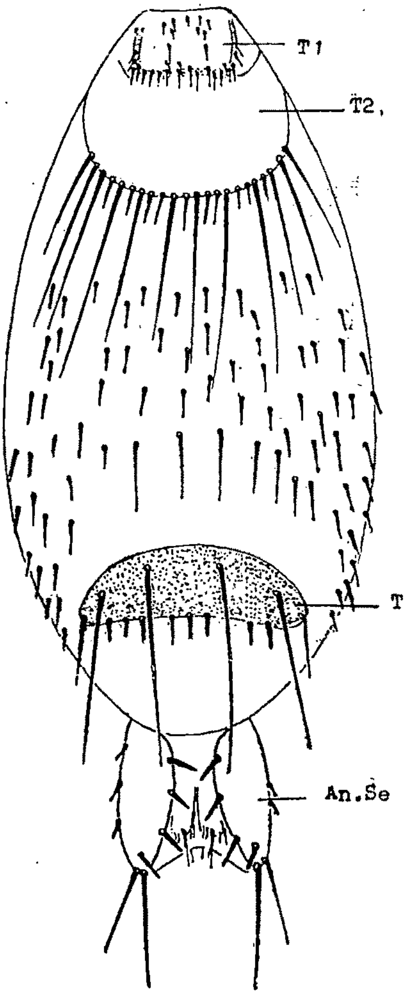


FIG. 14

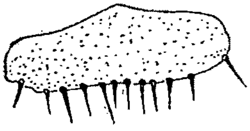


FIG. 16

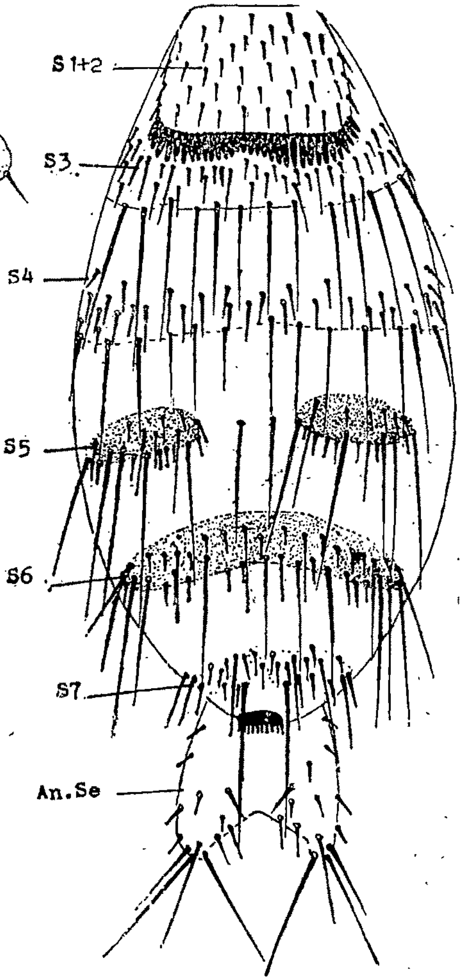


FIG. 15

FIG. 14. *Nycteribia allotopa.* Dorsal view of female abdomen. FIG. 15. Ventral view of female abdomen. FIG. 16. Genital plate.

triction and consists of two lateral pieces, separated dorsally and united ventrally. A row of 3-4 moderately long spines on the inner margin of each plate and two long ones on the posterior rounded corners.

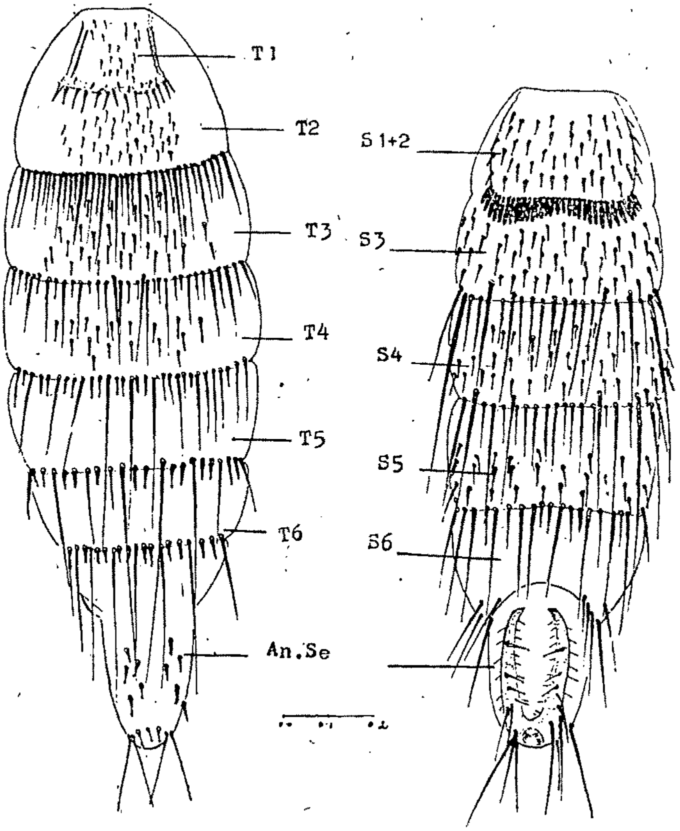


FIG. 17. *Nycteribia allotopa.* Dorsal view of male abdomen and FIG. 18. Ventral view of male abdomen.

Sternite 1+2 with short hairs on the surface. Hind margin of the ctenidium concave in the middle, bearing 30-32 pointed teeth. Sternite 3 with a row of long setae at the hind margin and 2-3 irregular rows of short hairs, near the posterior border. Sternite 4 covered with a row of uniformly long setae at the posterior border and 2-3 rows of short hairs on the surface, anterior to hind border. Sternite 5 divided into two lateral halves each with a double row of long and short hairs at the posterior margin and a few short ones on the disc. Two long setae between the plates on the soft integument. Sternite 6 in the form of a long transversely elongated plate with a row of long and short setae at the concave posterior margin and also a few scattered ones on the surface. Sternite 7 with a few short spine-like setae and long ones at the hind margin. Anal segment convergent posteriorly, as well as anteriorly. Its surface covered with a few scattered setae at the sides and 2-4 long ones at the rounded hind corners.

Dorsal plate (Fig. 16) transversely elongated, with a projection in the middle of the anterior border and the posterior border bearing 12 short setae. Ventral plate absent.

Abdomen in male : Tergite 1 similar to that of female but narrower. Post-spiracular sclerite (Fig. 19) small with two long setae. Tergites 2, 3 and 4 with numerous short hairs in the middle of the disc. Hairs on tergite 4, fewer than those found on tergites 2 and 3. Hind margin of tergites 2 and 3 carry long setae, with 1-2 short ones in between them; the long ones extending upto the hind margin of the following segment. Tergites 4, 5 and 6 with long setae and 1-2 short spine-like ones interspersed between the long setae at the posterior margin. Tergites 5 and 6 smooth. Anal segment long, with a few short setae in the posterior half of the surface and 2-4 moderately long ones, at the hind corners.

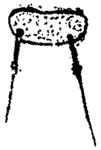


FIG. 19

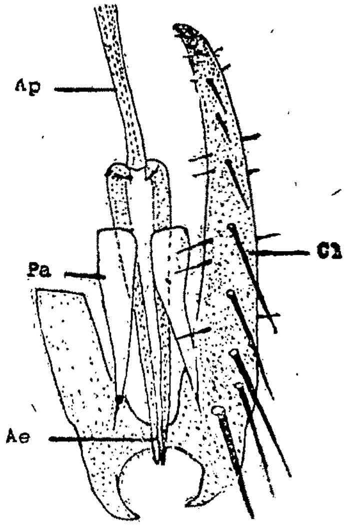


FIG. 20

FIG. 19. *Nycteribia allotopa.* Posts-spiracular sclerite.
FIG. 20. *Nycteribia allotopa.* Male genitalia.

Sternite 1+2 as in female. Sternites 3 and 4 covered with small hairs on the surface and a row of long and short setae, at the posterior border. Sternite 5 with 2-3 rows of short setae, in the posterior half of the surface and a row of long and short setae at the hind border. Submarginal row of 4-6 long setae present on sternites 3 and 4. Short setae on sternite 5 spine-like. Sternite 6 smooth, with a few moderately long setae, at the hind end corners, in level with the claspers. Anal segment longer than broad, its sides being slightly convergent posteriorly bearing a few long setae.

Genitalia (Fig. 20) : Basal arc broad, rounded, with a short inconspicuous anterior process. Phallobase conical, with a dorsal hinge pigmented. Four short hairs present between the base of the phallobase and the basal arc.

Aedeagus long and pointed at the tip. Apodeme longer than aedeagus and broader at the end. Parameres with a pointed tip bearing a short seta and 2 slightly long ones near the base of the phallobase. Claspers rather curved inwards, tapering to a blunt dark tip. It bears a long seta at the base, some moderately long ones along the median line and short ones at the inner margin.

Host.—58 females and 40 males from *Miniopterus fuliginosus*, Mahabaleshwar, Bombay State, June 1952.

Specimens of this species along with those of *Nycteribia parvula* and *Penicillidia jenynsi* var. *indica* were collected from Mahabaleshwar. It is often difficult to separate this species from *Nycteribia parvula* but the female of *N. allotopa* has a well developed bilobed anal segment, and the male has a slender and longer abdomen. The Indian specimens differ from the Formosan forms in having the hind margin of tergite 2 in female acruate instead of straight and bare and the transverse plate behind tergite 2, much elongated with the hind margin concave and anterior convex, instead of being not so much elongated with the margins straight.

3. **Nycteribia (Listropodia) parvula** Speiser, 1901

(Figs. 21-30)

Scott (1908) described this species with figures, for the first time, under the name *Nycteribia sauteri* from *Miniopterus schreibersi* at Formosa. Ferris (1924) figured it from Philippines, but the figures seem to differ from the former. Subsequently in 1925, Scott pointed out that the Indian material differs from the Formosan specimens in the anal segment of the female, having a regular series of 6-7 short setae anterior to the middle and the indications of the posterior series, being interrupted in the middle, while the Formosan specimens possess

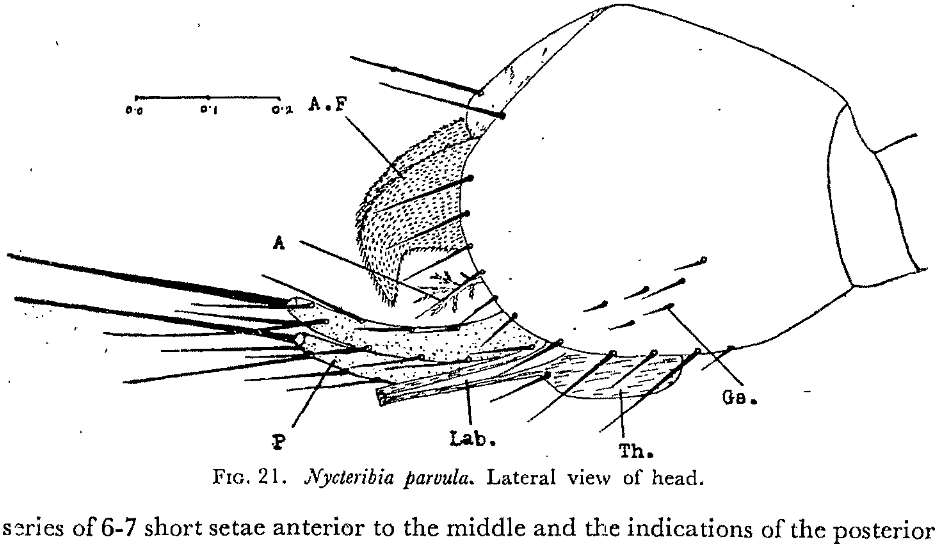


FIG. 21. *Nycteribia parvula.* Lateral view of head.

only 2-3 short setae on the dorsal surface. A good number of specimens of this species were obtained from Mahabaleshwar. They differ from the Formosan specimens in the following chief characters:—

(1) The chitinous plate on the dorsal surface of female is twice or a little more than twice as broad as long, with a pair of very short hairs in the middle of the surface, while in the Formosan specimens it is as long as broad and bearing no hairs.

(2) Sternite 3 in female has the whole surface covered with short hairs and in the Formosan specimens it is covered with only two irregular rows anterior to the hind border.

In addition there are some other minor differences in the number and arrangement of setae on the body. Moreover, the genitalia has been studied for the first time.

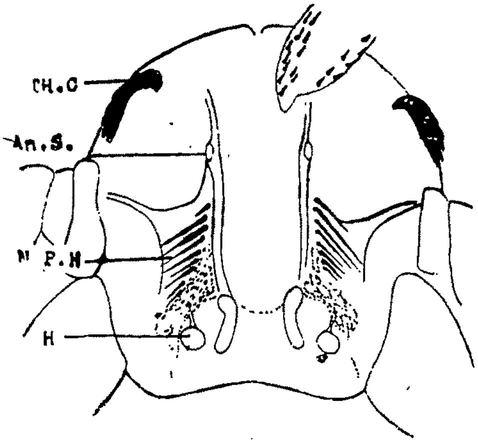


FIG. 22

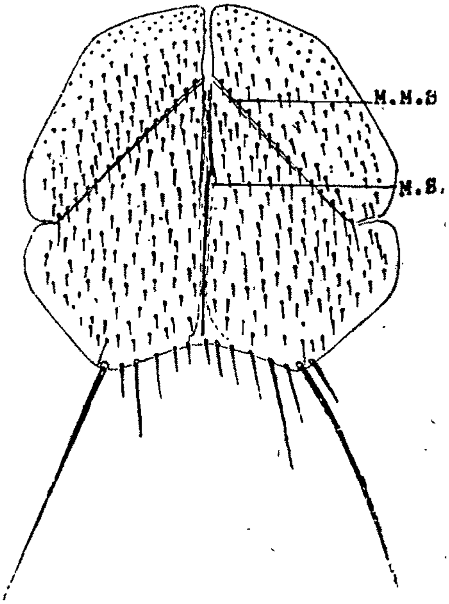


FIG. 23

FIG. 22. *Nycteribia parvula.* Dorsal view of thorax.
FIG. 23. *Nycteribia parvula.* Ventral view of thorax.

Length 1.8—2 mm. in both sexes.

Head : Moderately long and compressed laterally. Anterior part of the head membranous, bearing 2-4 widely placed setae on the vertex. A row of short setae along the anterior margin and 4-6 short setae on the genae. Labella longer than theca.

Thorax : Broader than long. Length 0.58 mm. Breadth 0.64 mm. Ctenidium with about 20 pointed teeth. Median sternal suture flattened in the middle. Oblique sutures well marked, straight, joining the median suture

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at an acutea ngle. Mesonotal suture clear, with a row of 10-11 elongated hairs. Posterior margin of the ventral surface of thorax with a row of short setae and a long one at the sides. Tibiae short, broad, 2·5 times as long as broad, with a curved ventral edge bearing three rows of setae in its distal half.

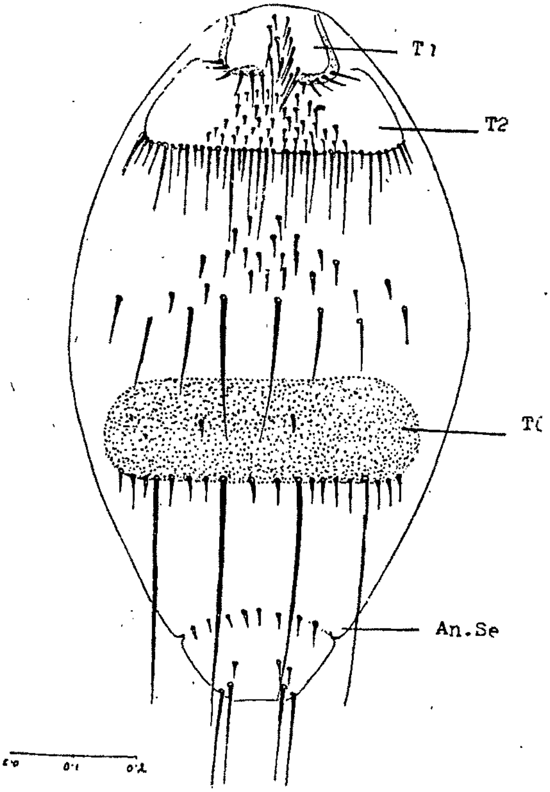


FIG. 24. *Nycteribia parvula.* Dorsal view of female abdomen.

Abdomen in female : Tergite 1 short, with a few hairs on the disc and at the posterior border. Tergite 2 broad, with the hind margin arcuate. Its surface bears a patch of short hairs in the form of triangle and the hind margin having long setae alternating with 1-2 short, spine-like setae. The connexivum behind the tergite 2 with about 25 setae in the middle, which are longer posteriorly. Of these, a few long setae in the middle of the hind row, longer than the lateral ones. Chitinous plate posterior to these setae, twice as broad as long, rectangular, with the sides rounded, bearing on its hind margin 4 long setae, widely separated from each other and interspersed with 2-4 short and stiff setae between them. A pair of short spine-like setae on the surface. In the Formosan specimens this plate has a smooth surface and its breadth less than twice its length. Anal segment with a regular transverse series of 6-7 short setae in the middle of the surface, 2-4 short setae near the posterior margin and 2 long ones at the hind corners.

Sternite 1+2 mostly covered with short setae upto the anterior border. Ctenidium with long, pointed, numbering to about 44 teeth and concave in the middle of the posterior border. Sternite 3 covered with short setae while in the Formosan specimens, there are only two rows anterior to the hind border. Sternite 4 partly covered with 2 rows of short setae near the hind margin. A row of long setae, widely spaced-out, at the posterior border of sternites 3-4. Sternite 5 with two lateral plates, separated medially by a small gap. A row of long and short setae, at their posterior border and the surface smooth. Sternite 6 composed of a single transversely elongated plate, with the hind margin slightly convex bearing a row of long and short setae, of which 1-2 at the sides are longer than the middle. A small row of 4-6 short setae, anterior to the posterior margin in the middle. Sternite 7 with two elevated chitinous plates, separated from each other by a narrow gap, each plate bearing long and short setae at the posterior margin and the surface smooth. Anal segment short but broad posteriorly,

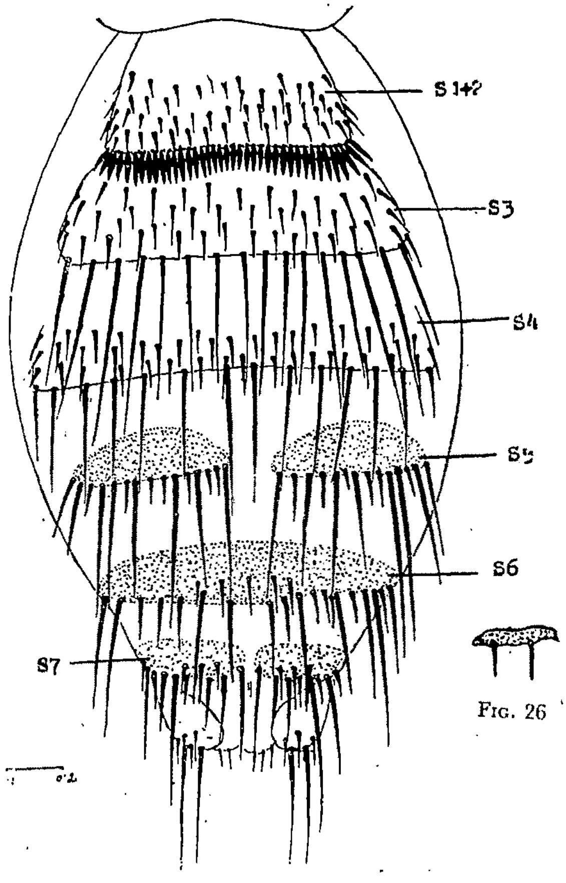


FIG. 25

FIG. 26

FIG. 25. *Nycteribia parvula.* Ventral view of female abdomen. FIG. 26. Genital plate.

with its rounded corners having 2-4 long and a few short setae. Genital plate (Fig. 26) single, small, in the form of a transverse strip, with two short setae on the hind margin. Ventral plate inconspicuous.

Abdomen in male : Tergite 1 similar to that of female. Post-spiracular sclerite (Fig. 29) bean-shaped, with 3 long setae. Tergite 2 as in female, covered with numerous short hairs in the form of triangle and the hind margin with a row of long and short setae, the long ones extending upto the hind border of the next segment. Tergite 3 like the 2nd, sparsely covered with moderately long setae. Tergite 4 with a few setae as on tergite 3 but the setae being distributed in the middle. The hind margin of tergite 3 bears a row of long and short setae. Tergite 5 with 2-3 short hairs in the middle of the disc and tergite 6 bare. Tergites 4, 5 and 6 with a row of long setae, intervened by 1-2 spine-like setae, between

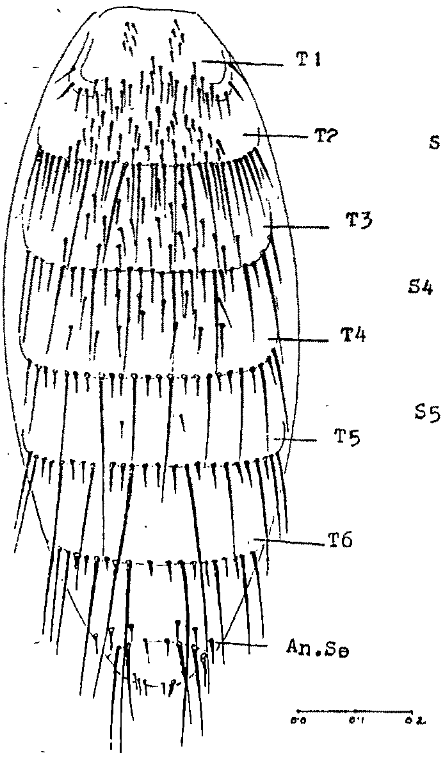


FIG. 27

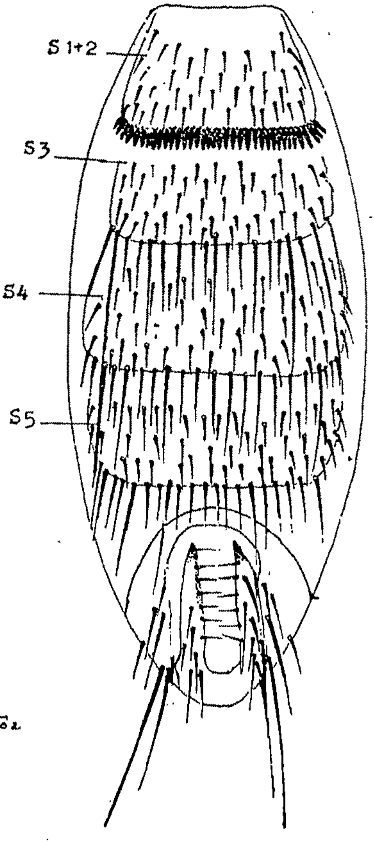


FIG. 28

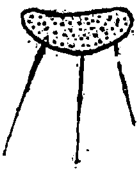


FIG. 29

FIG. 27. *Nycteribia parvula.* Dorsal view of male abdomen. FIG. 28. Ventral view of male abdomen. FIG. 29. *Nycteribia parvula.* Post-spiracular sclerite.

the long ones and 1-2 long setae still longer in the middle along the posterior border. Anal segment short, broad anteriorly, with a row of few short hairs in the posterior region and 2-4 long ones at the corners of the hind margin.

Sternite 1+2 as in female. Sternites 3, 4 and 5 covered with short hairs. Hind margin of each sternite with long and short setae directed outwards. Anal segment rounded posteriorly, having a few long and short setae at the sides towards the hind margin.

Genitalia (Fig. 30). Basal arc rounded, with a short anterior process. Phallobase conical, pigmented, with a few short hairs on the base ventrally. Aedeagus long, slender, pointed distally and lies in close apposition with the parameres. Apodeme longer than aedeagus, with a wing-like expansion distally. Parameres with a pointed tip, and without any hairs, except a row of small hairs ventrally. Two groups of small hairs, between the base of the phallobase and the basal arc. Claspers rather broad, straight, tapering to a point

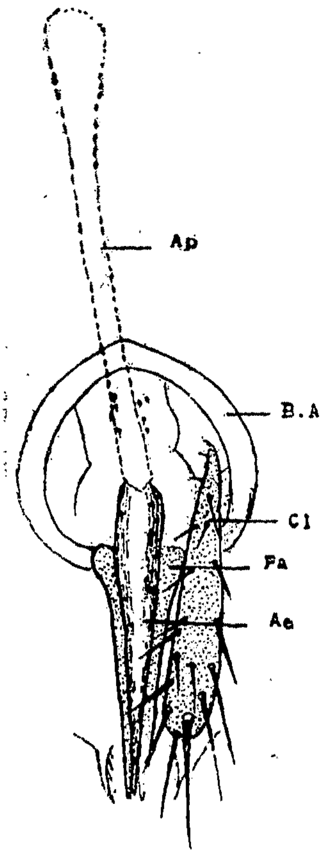


FIG. 30. *Nycteribia parvula.* Genitalia.

distally, with the arms parallel, bearing 1-2 long, stout setae at the base, moderately long ones in the basal half and short ones near the tip.

Host.—39 females and 30 males from *Miniopterus fuliginosus* Mahabaleshwar, Bombay State, June 1952.

The general distribution is Sumatra, Formosa, Philippines, Japan, Ceylon and India.

Genus **Penicillidia** Kolenati, 1863

Speiser (1901) redefined this genus chiefly on the presence of a single ocellus, distinguishing it from *Nycteribia* possessing no ocelli. In addition, there are other characters differentiating these two genera. 3 European species were described under the genus *Penicillidia* and subsequently many more have been added from the Indo-Australian and Palaearctic Regions.

4. **Penicillidia fletcheri** Scott, 1914

(Figs. 31—39)

This species was described by Scott (1914) on *Pipistrellus dormeri*, from Coimbatore. In the course of study of Nycteribiids, the authors came across a few specimens of this species from Dharwar in 1952 and found that the Dharwar specimens show the following variations

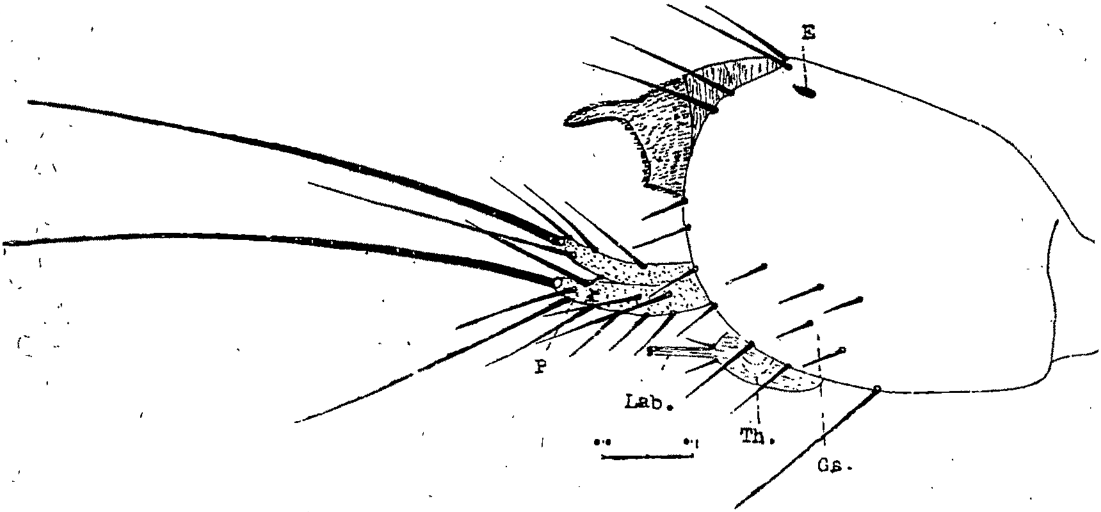


FIG. 31. *Penicillidia fletcheri.* Lateral view of head.

(a) In female, tergite 1 is well marked off from the rest of the abdomen and bears a row of long setae at the posterior border, while in Scott's material it is small with short hairs.

(b) The sternite 3 in male with 2 irregular rows of short hairs, instead of one, as described earlier.

The original description of this species by Scott (1914) is brief as the material at his disposal was not fit for detailed study. Hence, an opportunity is taken to redescribe this species here with a complete set of figures. A description of male and female genitalia has also been added, as it is of great taxonomic importance. It will be interesting to study in future the genitalia of the material from the Southern India for comparison with the genitalia of specimens from the Bombay State.

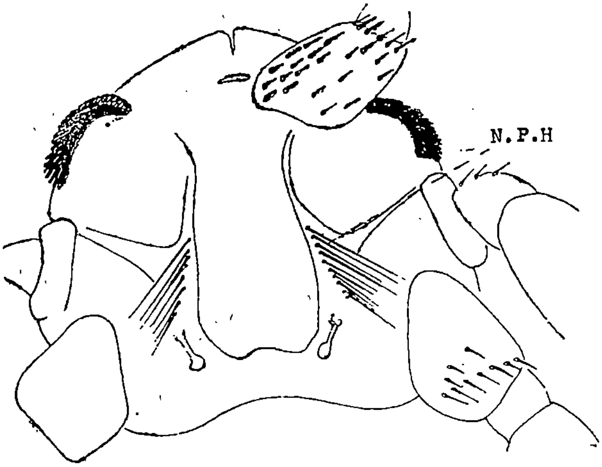


FIG. 32. *Penicillidia fletcheri.* Dorsal view of thorax.

Length 2.4-2.8 mm. in both sexes. *Colour* Light brown to yellowish brown.

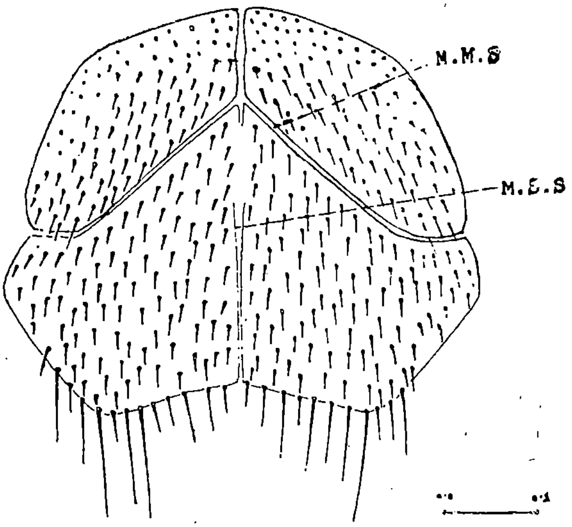


FIG. 33. *Penicillidia fletcheri.* Ventral view of thorax.

Head : Smooth with the exception of a few moderately long setae on the anterior margin of vertex and a few short ones, along the anterior margin of cheeks. Palps flattened, styliform, scantily covered with long bristles on the lateral surface and a stout one at the tip. Genae with 4-6 short setae. Labella shorter than theca.

Thorax : 1¼ times broader than long, with the ventral surface almost flat and covered with minute hairs. Mesonotum wide posteriorly. A row of 10-12 notopleural hairs starts from the mesonotal suture and runs more or less straight posteriorly. Median sternal suture faint in the middle and impressed towards the hind margin. A fringe of 10-12 short setae, interspersed with 4-6 long ones, at the sides of the posterior margin. Front coxa 1¼ times broadre than long and sparsely covered with short setae dorsally. Femora covered with short setae, getting longer towards the distal end and of these 3-4 long on the dorsal surface. Tibiae as long as femur, with erect short setae on the dorsal surface and bare ventrally, except 3 rows at the distal half. Metatarsus half as long as tibia.

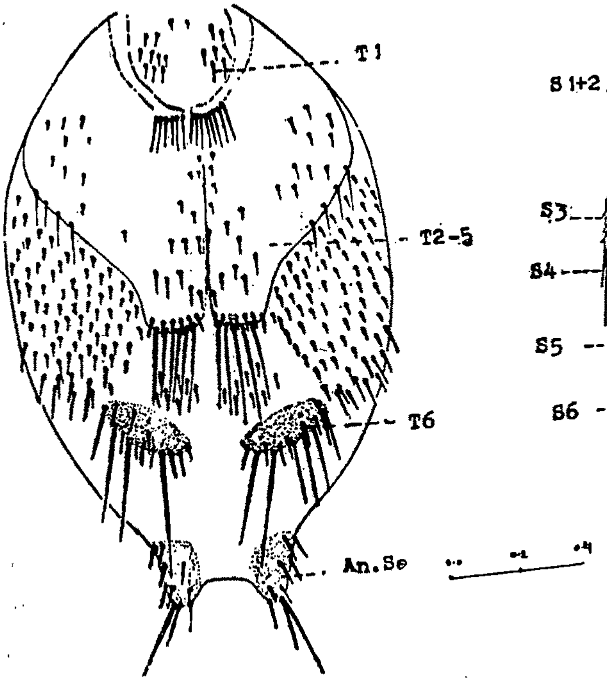


FIG. 34

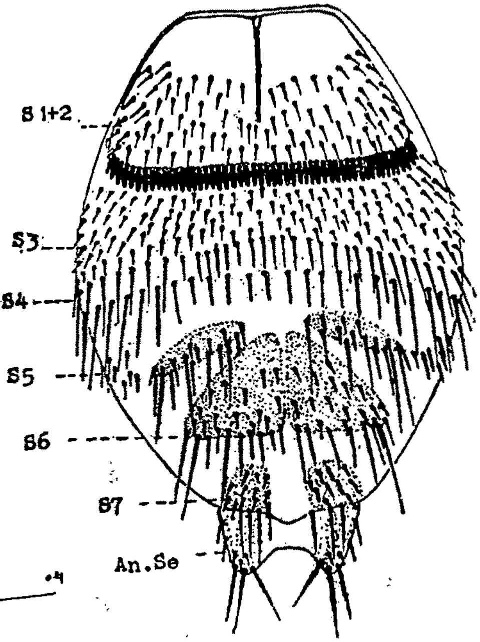


FIG. 35

FIG. 34. *Penicillidia fletcheri.* Dorsal view of female abdomen. FIG. 35. Ventral view of female abdomen.

Comparative lengths of femur and Tibia

	Femur	*Tibia*
1st pair of legs	0.8 mm.	0.7 mm.
2nd pair of legs	0.8 mm.	0.8 mm.
3rd pair of legs.....................	1.0 mm.	0.9 mm.

Abdomen in female : Tergite 1 narrow, pigmented at sides and rounded with two broad posterior lobes or processes, each bearing 5-7 long setae. A group of few short hairs on the surface of each of the lobes. Tergites 2-5 fused into a heart-shaped plate, completely divided into two halves, along the middle, ending in two broad processes, bearing 5-6 long setae at the hind margin and a row of 6-7 short spine-like ones in front of the long setae. A darkly pigmented strip runs from the posterior process along the median line. A row of moderately long setae at the posterior part of the lateral border of the plate. A few short hairs scattered over the disc, 8-10 short ones towards the sides and along the median line. Tergite 6 consists of two slightly elevated chitinous plates, separated from each other medially by a wide gap. Each plate twice as broad as long, with a few short hairs, on the surface and 5-7 long setae interspersed with 1-2 short ones at the posterior border. Sides of the abdomen covered with numerous short and long hairs in level with the plates of tergite 6. The connexivum in front of tergite 6 bears moderately long setae separated from the setose area, by

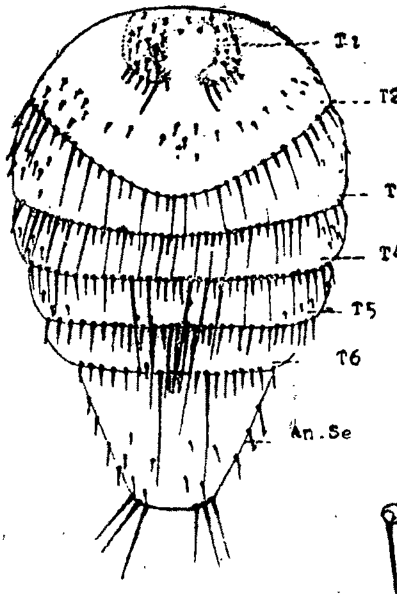


FIG. 37

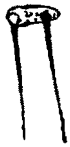


FIG. 36

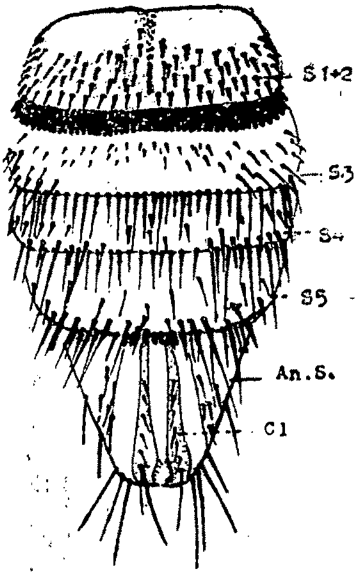


FIG. 38

FIG. 36. *Penicillidia fletcheri.* Dorsal genital plate. FIG. 37. Dorsal view of male abdomen. FIG. 38. Ventral view of male abdomen.

a narrow smooth area. Anal segment slightly tapering posteriorly, with the hind margin emarginate and the surface bare except a few spine-like setae near the posterior margin and 2-4 long ones at the hind corners.

Sternite 1+2 rounded anteriorly, with a ctenidium of about 50 long teeth. Surface covered with small hairs, excepting the anterior part and with a slightly impressed median line. Sternite 3 membranous, bearing short hairs on the surface and a row of long setae, at the posterior margin being longer at the sides. Sternite 4 narrow, bare, with setae at the hind margin as on sternite 3. Sternite 5 consists of two elongated plates, separated by a wide gap, each plate bearing long as well as short setae at the hind border and a few short ones on the surface. Sternite 6 with two yellowish, roughly triangular plates, separated from each other by a narrow membranous streak. Each plate bears 7-10 setae longer at the sides of the hind border and a few short ones on the surface, except towards the anterior corners. Sternite 7 bare in the middle, with a few short, suberect setae at the sides. Anal segment highly chitinised, bearing 2-4 long setae on the lateral margin. Dorsal genital plate (Fig. 36) small, poorly chitinized, with 2 long setae. Ventral genital plate absent.

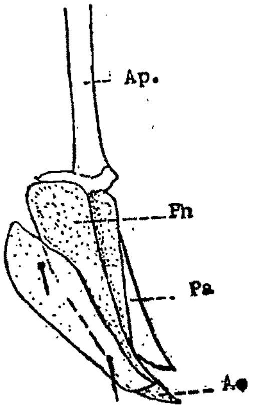


Fig. 39. *Penicillidia fletcheri.* Male genitalia.

Abdomen in male : Tergite 1 small, roughly circular, with 4-6 slender setae at the hind margin, on either side of the middle membranous part and 6-10 short ones anterior to the hind margin. Tergite 2 with 20-25 short, slender hairs on the disc and long and short setae at the posterior border. Tergites 3,4,5 and 6 bare, but with a few short hairs at the sides anterior to the hind border. From the hind border of each tergites arise long setae, alternating with 1-2 short ones, the middle setae longer than the laterals. A wide concave gap, without hairs, in the middle of the hind margin of tergite 6. Anal segment conical, the surface having 6-8 spine-like setae, on the posterior half, a few short setae at the sides and several long ones at the tip.

Sternite 1+2 similar to that of female. Sternite 3 covered with 2 or 3 irregular transverse rows of short hairs, which are shorter still in the middle. Sternite 4 with two rows of hairs, broken in the middle. The hind margin of sternites 3 and 4 with long setae at the sides and a little shorter ones along the hind margin. Sternite 5 bare, except a row of slender, long and short hairs in the middle, anterior to the hind border. In addition, sternite 5 bears a row of 8-11, short, thick, thorn-like spines, in the middle of the hind border. Anal segment with a few short hairs towards the sides and the lateral margins.

Genitalia : Basal arc rounded, with a long anterior process. Claspers long, slightly tapering to a point, with a row of long hairs, in the basal half and longer still near the base. A few short hairs upto the tip. Aedeagus long, with a wide posterior plate, 2½ times as long as the aedeagus. Parameres short, broad at base curved distally, with 1-2 short hairs on the lateral surface. A row of 3 long hairs between the base of the phallobase and the basal arc.

Hosts.—4 females and 3 males from *Pipistrellus ceylonicus chrysothrix* Dharwar (Bombay State) June 1952. Scott (1925) recorded it from an unknown bat at Bangalore and from a house-bat at Coimbatore.

5. **Penicillidia Jenynsi** var. **indica** Scott, 1925
(Figs. 40-46)

Speiser (1901) and Scott (1908) described *Penicillidia jenynsi* from *Miniopterus schreibersi* at Formosa. In 1925, Scott, while recording it from India on *Miniopterus fuliginosus* stated that the Indian material differs from the Formosan specimens in having sternite 4 in male, with the hind margin obtuse instead of broadly arcuate and its surface bearing a group of small hairs filling the angle.

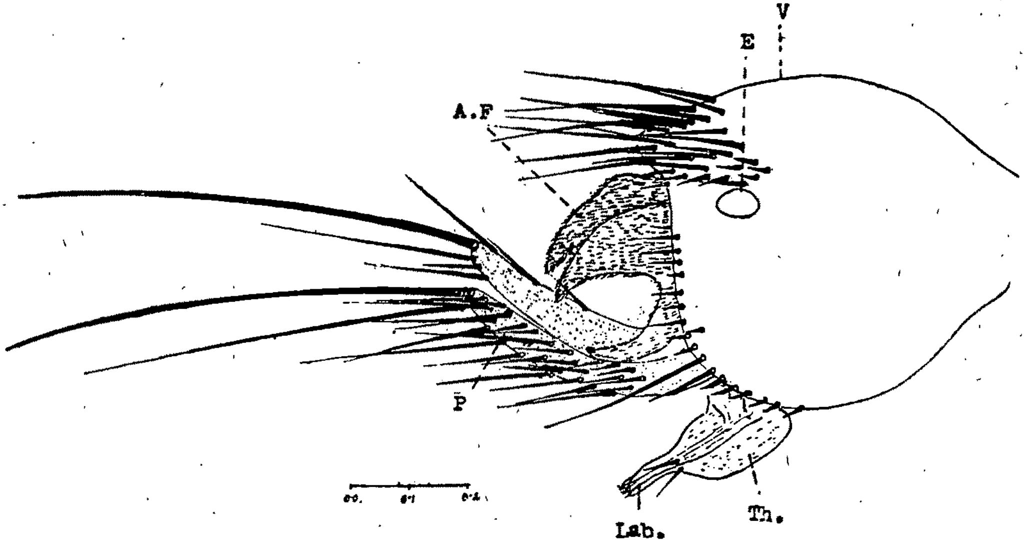


FIG. 40. *Penicillidia jenynsi* var *indica*. Lateral view of head.

He, therefore, grouped his material as a variety, under the name *P. jenynsi* var. *indica* and published a figure of the ventral surface of male abdomen only. The Indian form differs further in having tergite 3 in female with two chitinous plates instead of one and the two plates on the ventral side, bearing numerous setae, instead of being bare. A complete description of *P. jenynsi* var. *indica*, with a number of illustrations is given below along with genitalia. In view of the above

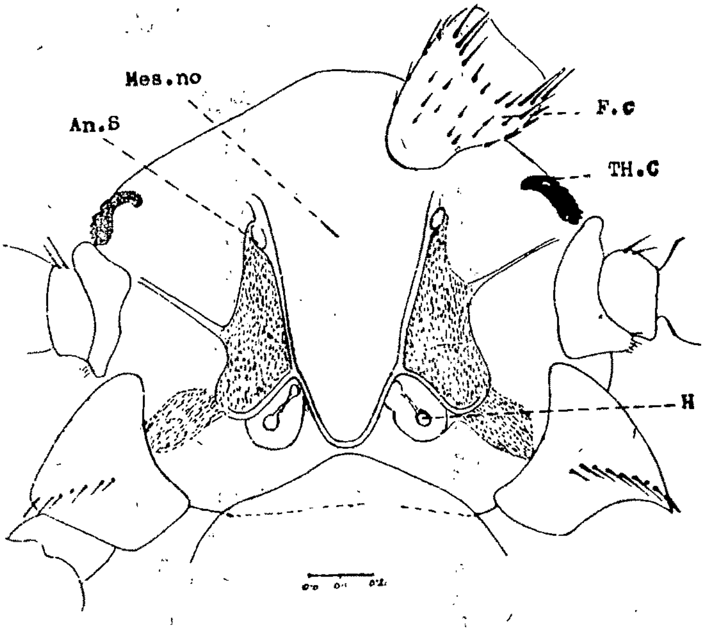


FIG. 41. *Penicillidia jenynsi* var *indica*. Dorsal view of thorax.

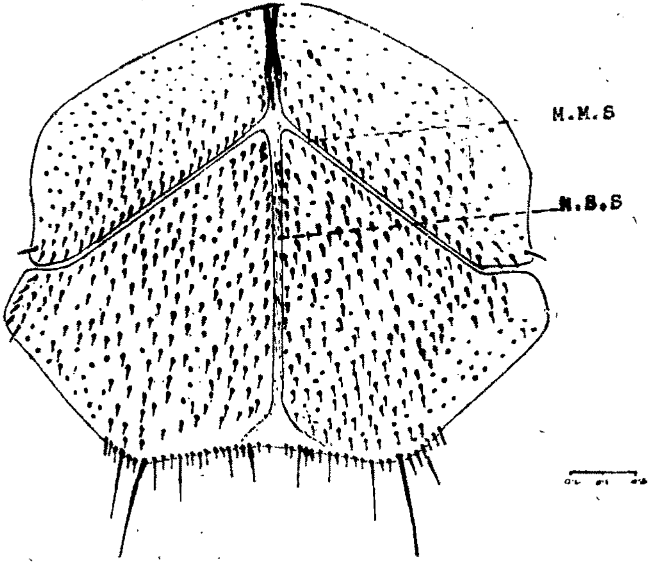


FIG. 42. *Penicillidia jenynsi* var. *indica*. Ventral view of thorax.

mentioned differences between the Indian and Formosan specimens, *P. jenynsi* var. *indica* may be given a status of a species.

Length 3.1-3.5 mm. in both sexes. *Colour* Yellowish-brown in mounted slides.

Head : Nearly as long as broad and moderately compressed laterally. Vertex with numerous strong setae in between the eyes. Eyes consist of a single ocellus. A few short setae along the anterior border of the cheeks with two exceptionally long ones. Palps thick, with several dense rows of long and short setae on the inner surface and at the tip. Labella shorter than theca.

Thorax : 1¼ times longer than broad, with the ventral surface markedly curved along its longitudinal axis and uniformly covered with numerous short hairs. A few short and long setae arise from the posterior border of the thorax.

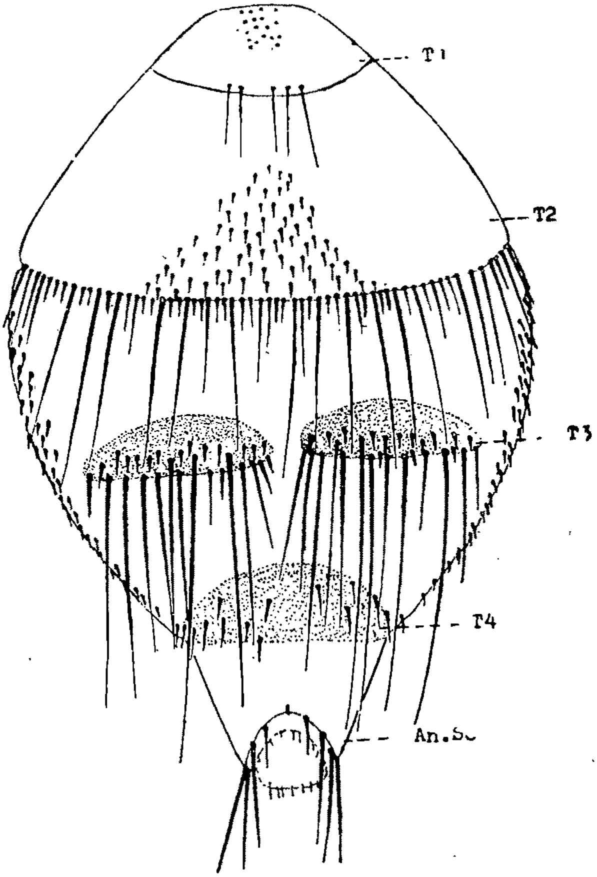


FIG. 43. *Penicillidia jenynsi* var. *indica*. Dorsal view of female abdomen.

Median sternal suture short and not expanded in the middle. Dorsal pattern; mesonotal space wide anteriorly. Anterior spiracles oval. Lateral plate of notopleural sutures elongated, without any notopleural hairs. Legs comparatively thick and strong. Tibiae scalpel-shaped, slightly shorter than the femur with 3-4 rows of long setae distally.

Abdomen in female : Tergite 1 small, much wider than long, sides rounded and without any identation in the middle of the hind margin. A row of 4-6 short setae in the middle of the hind border. A group of small hairs in the middle of the surface. Tergite 2 broad, faintly divided into two halves by a median longitudinal thinning, clearly seen in alcohol preserved specimens. Its surface, medially occupied by a triangular patch of small hairs as in *P. jenynsi* and a row of long and short setae at the posterior margin. Tergite 3 poorly chitinized, with two chitinous plates instead of one as in *P. jenynsi*, with the hind margin of each, bearing long and short setae and a few scattered ones anterior to the hind border. Tergite 4 with a small, elongated, poorly chitinized area, being covered with a few, scattered short hairs. Anal segment conical, bare with a few long setae at the hind corners and 1-2 long ones anterior to them.

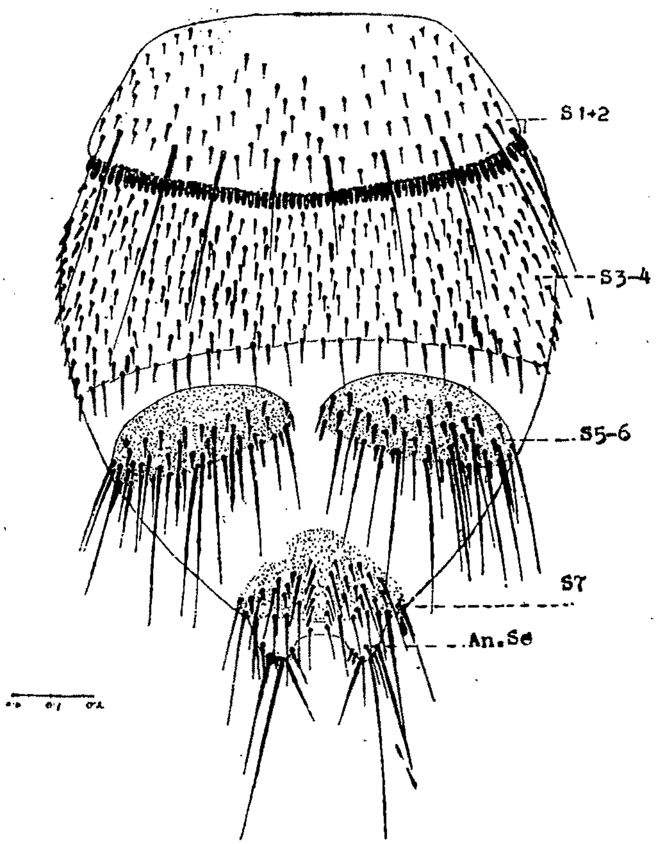


FIG. 44. *Penicillidia jenynsi* var. *indica*. Ventral view of female abdomen.

Sternite 1+2 nearly rectangular, narrow, with a ctenidium of 50-60 short, flattened and pointed teeth, standing rather apart. Its surface covered with small hairs anteriorly and 10-12 long setae posteriorly. Sternites 3-4 membranous, covered with short hairs anteriorly and longer ones posteriorly. Sternite 5-6 divided into two well defined chitinous oval plates, placed obliquely, bearing long and short setae on their hind border and a few scattered short hairs on their surface. Sternite 7 triangular, with a faint median longitudinal thinning the surface bearing numerous short setae in the posterior half and long and short ones at the hind border. Dorsal genital plate (Fig. 45) small, triangular, with a blunt apex anteriorly. Its rounded posterior border with 4 short hairs. Ventral plate narrow, wider posteriorly than anteriorly and without any hairs.

Abdomen in male : Tergites 1, 2 and 3 clothed with fine bristles while the tergites 4 and 5 are smooth. On the posterior border all tergites have long and short setae. Tergite 4 wider than long with the posterior border acruate. Anal segment with a few hairs posteriorly.

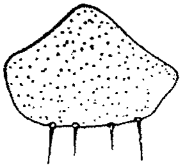


Fig. 45

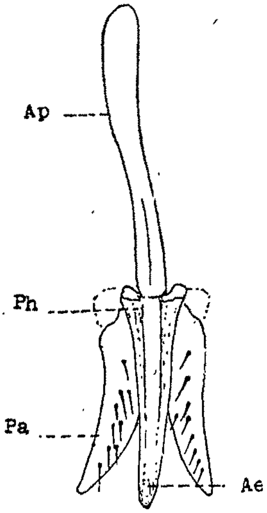


Fig. 46

Fig. 45. *Penicillidia jenynsi* var. *indica.* Dorsal genital plate.
Fig. 46. *Penicillidia jenynsi* var. *indica.* Male genitalia.

Sternite 1+2 as in female. Sternite 3 smooth, except a few hairs at the sides. Sternite 4 similar to sternite 3 but the hairs at the margins anterior to the hind border a little longer and directed outwards. Sternite 5 with its hind margin obtuse instead of acruate as in *P. jenynsi* and its disc divided into two halves by a faint median longitudinal line. Its surface covered mostly with numerous small hairs and 4-6 long hairs in the middle. From the hind margin of each sternite arise long and short setae rather spaced out. Anal segment convergent posteriorly, with the lateral borders nearly straight and with a few short hairs at the sides.

Genitalia : Basal arc nearly circular. Phallobase broad, triangular with a few fine hairs on the base. Aedeagus short, thick with a rounded tip. Apodeme longer than aedeagus being slightly expanded in its distal half. Parameres narrow, curved, pointed distally with their dorsal edge bearing fine hairs at the sides. Claspers thick, convergent towards apex, black and slightly curved upwards.

Hosts.—16 males and 20 females from *Miniopterus fuliginosus* Robbers Caves Mahabaleshwar, 1952. It is also recorded from Ceylon.

6. **Penicillidia bombayansis**, sp. n.

(Figs. 47-54)

Out of about dozen species recorded under the genus *Penicillidia*, *P. dufouri*, *P. jenynsi* var. *indica*, *P. fletcheri*, *P. bathybothyra* (*P. fletcheri* var. *pumila*) and *P. peal* arei known to occur in India. Of these, *P. dufouri* is purely a species of Palaearctic Region and is confined to the upper Himalayas. *P. bathybothyra* is not sufficiently known as Speiser's original description does not give important characters and many conflicting views have been expressed by some authors, regarding its occurrence in this country. Out of the remaining three species, *P. fletcheri* and *P. jenynsi* var. *indica* have been redescribed above in this paper. *P. peali* is known only from Assam and since then there are no records of it from other parts of India.

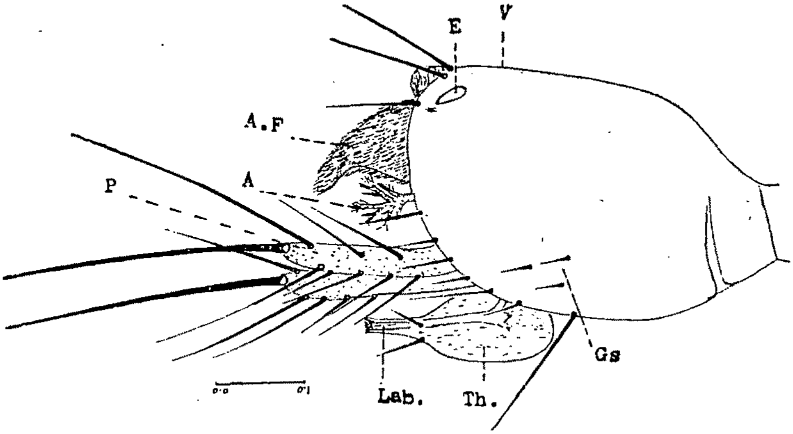


FIG. 47. *Penicillidia bombayansis*. Lateral view of head.

During the course of this investigation, 3 females and 2 males were obtained from house-bats in Bombay. This material differs from *P. jenynsi* var. *indica* in having tergite 2 in female heart-shaped with two posterior lobes and from *P. peali* in possessing short and numerous hairs instead of long and scanty hairs on tergite 2 in female. Besides it is much smaller in size than *P. peali*.

The only species that bears some resemblance to these specimens is *P. fletcheri* but the latter differs from them chiefly in having hairs medially on the connexivum behind tergite 2 in female and the hind margin of the ctenidium concave in the middle. In view of the above differences the specimens in hand have been placed under a new species *P. bombayansis.*

Length 1.7-1.8 mm. in both sexes. Colour yellowish-brown in mounted slides.

Head : Bare except 6 long setae in front of the vertex. Palps styliform with long setae on the external surface and an exceptionally long one at the tip. Eyes consist of a single ocellus. A row of short hairs along the anterior border of the cheeks. Genae with 3-5 short hairs. Labella shorter than the theca.

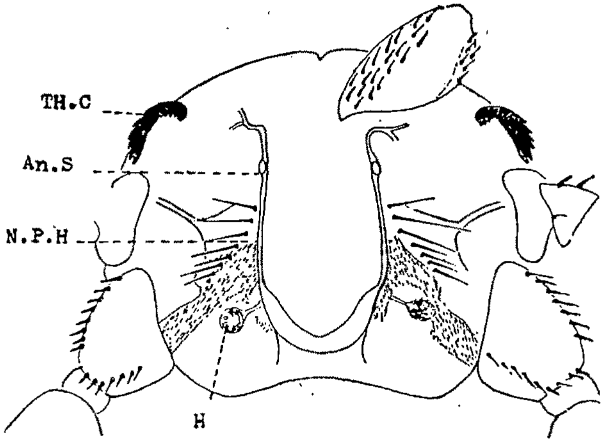


FIG. 48. *Penicillidia bombayansis.* Dorsal view of thorax.

Thorax: $1\frac{1}{2}$ times broader than long. Median sternal suture obscure medially and impressed posteriorly. Ventral surface almost flat and covered

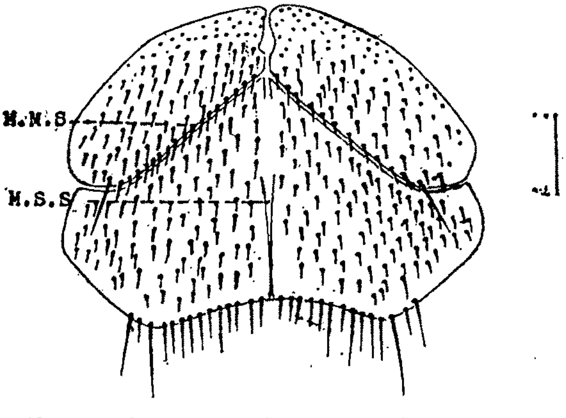


FIG. 49. *Penicillidia bombayansis.* Ventral view of thorax.

with numerous short hairs. Region anterior to the suture of the meso- and metasternum slightly reflexed. Along the hind margin arise short setae, of which 3-4 at the sides are longer. Dorsal pattern: Mesonotum wider posteriorly than anteriorly. Anterior spiracles oval. Notopleural plate elongated with 7-8 hairs starting from the mesonotal suture and running more or less straight posteriorly. Halteres small and exposed. Front coxa nearly as long as broad, covered with short hairs dorsally. Femur thick, with a clear ring near the middle and the dorsal surface studded with numerous short and 3-4 long hairs. Tibia almost as long as femur with numerous short hairs on the surface. Metatarsus as long as tibia.

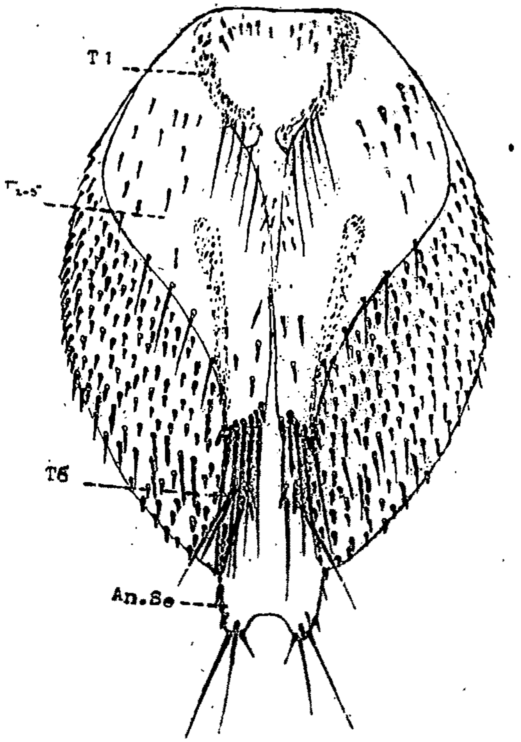


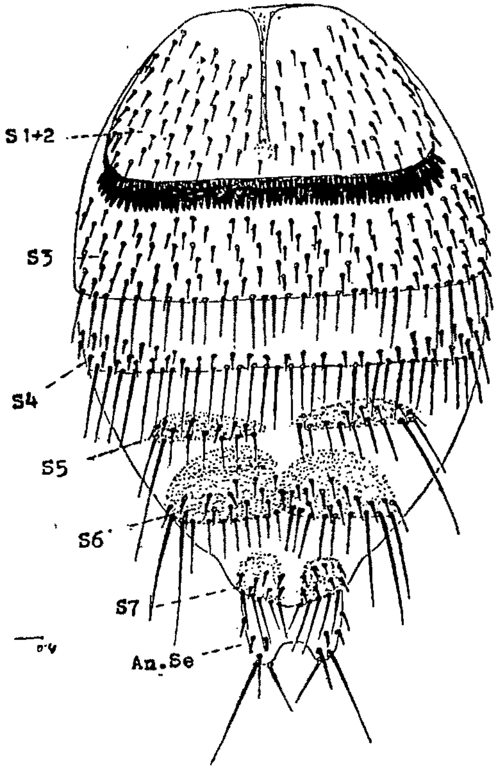
FIG. 50. *Penicillidia bombayansis.* Dorsal view of female abdomen.

Comparative lengths of femur and tibia

	Femur	*Tibia*
1st pair of legs	0.68 mm.	0.60 mm.
2nd pair of legs	0.78 mm.	0.62 mm.
3rd pair of legs	0.78 mm.	0.60 mm.

Abdomen in female : Tergite 1 longer than broad, nearly circular, with long and slender hairs at the posterior border. A few short hairs at the sides of the disc. Tergite 2-5 fused as in *P. fletcheri,* but appears to be a little longer than

P. fletcheri. It is incompletely divided into two lobes, each bearing 5 long setae at the hind margin and a row of 5-7 short spine-like ones in front of the long setae. A darkly pigmented strip along the median line from the posterior border. A row of four moderately long hairs along the posterior part of the lateral border of the margin. Its disc sparsely covered with hairs in the region anterior to the hind border of the lobes and along the median longitudinal line. At the sides the hairs are confined to the concavities and convexities of the tergite. Tergite 6 consists of two small, slightly elevated plates, separated from each other by a narrow gap. Each plate bears two long, two short setae at the posterior border and 1-2 smaller ones anterior to them. The connexivum between the tergite 5 and 6 membranous and bare, while at the sides it is setose. Anal segment conical, emarginate, smooth with 2-4 long setae at the hind corners.



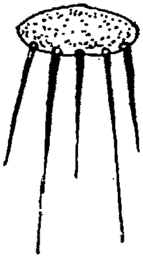


FIG. 52.

FIG. 51. *Penicillidia bombayansis.* Ventral view of female abdomen.
FIG. 52. *Penicillidla bombayansis.* Dorsal genital plate.

Sternite 1+2 covered with short hairs, except a small area behind the thorax. Median longitudinal impression obscure posteriorly and the hind margin of the ctenidium convex instead of concave as in *P. fletcheri.* Sternite 3 covered with short hairs and long setae at the posterior border. Sternite 4 narrow, bare except a row of short hairs in the middle and two rows of hairs at the sides anterior to the hind border. The hind border as in sternite 3, with long setae of the same length. Sternites 5 and 6 consist of two plates, each separated medially by a wide gap in sternite 5, and by a narrow gap in sternite 6. Plates of sternite 6 bigger, oval in shape and that of sternite 5 small, transversely elongated, each with a row of short setae and 1-2 long ones at the sides of the hind border and a few short ones anterior to them. Sternite 7 small, bare in the middle and at the sides with a few short hairs and 4-5 moderately long ones at the posterior border. Anal segment smooth with 2-4 spine-like setae near the corners of the hind margin. Dorsal genital plate (Fig. 52) bigger than that of *P. fletcheri* bearing 3 short and 2 long hairs. Ventral genital plate absent.

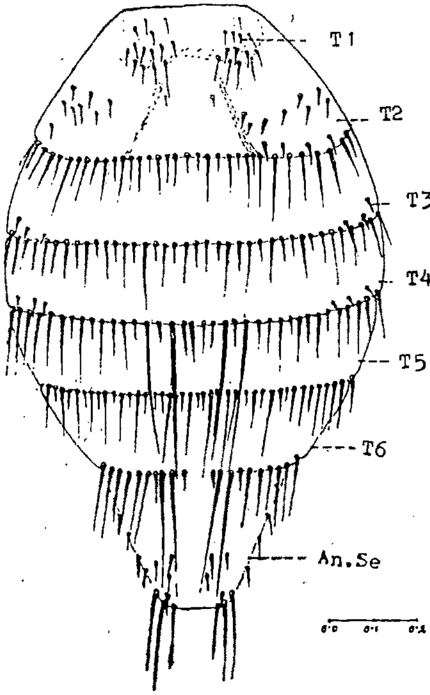


FIG. 53

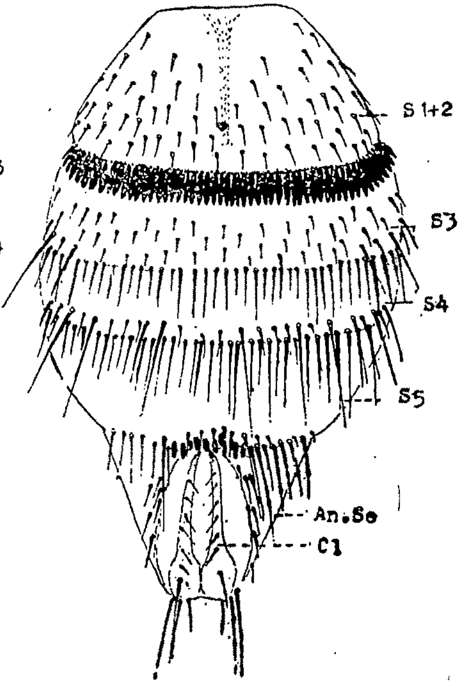


FIG. 54

FIG. 53. *Penicillidia bombayansis.* Ventral view of male abdomen. FIG. 54. Dorsal view of male abdomen.

Abdomen in male : Tergite 1 broader than long, poorly chitinized, the hind border with slender hairs on slightly elevated lobes and a few short ones at the sides anterior to them. Tergite 2 unlike that of *P. fletcheri* much wider, with the hind margin almost straight, bearing long and short setae. Two narrow, darkly-pigmented strips run from the hind border medially and obliquely towards the anterior border. A few short hairs are scattered on the lateral regions of the disc and medially bare. Tergites 3,4 5 and 6 narrow, smooth, with long and short setae at the posterior border and 1-3 short ones at the sides anterior to the hind border. About 2-4 setae in the middle of the hind border of the tergites are much longer, extending across the succeeding segment. Tergite 6 small, with a break in the middle of a row of setae at the hind border. Anal segment conical and the surface covered with a few spine-like setae in the posterior half of the surface.

Sternite 1+2 as in female. Sternite 3 covered with short hairs, shorter in the middle than at the sides. A row of long and short setae at the posterior border and 1-2 long ones anterior to it near the corners. Sternite 4 narrow, bare except a row of long and short setae anterior to the hind border. Sternite 5 small, convex posteriorly, smooth bearing a row of 10-12 short thick spines in the middle and with long setae laterally along the posterior border. Anal segment bears a few short hairs towards the sides and at the lateral margins.

Genitalia : Basal arc short, without any conspicuous process anteriorly. Aedeagus small, not well sclerotised. Phallobase curved, broad at base, without any hairs. Parameres short, curved and smooth. Two to three short, slender hairs between the base of the phallobase and the basal arc. Claspers similar to *P. fletcheri*, more curved and the apex darkly pigmented.

Host.—3 males and 2 females from *Pipistrellus ceylonicus chrysothrix* Bombay, March, 1952.

Genus **Basilia** Mir. Ribeiro, 1903

The genus *Basilia* was first erected by Ribeiro (1903) for a South American species. Most of the species belonging to this genus are known from the New World and very few are recorded from the Old World. In one species *B. eileenae* of the latter region, the tibiae are expanded and laterally compressed, resembling the subgenus *Listropodia* of *Nycteribia* while in others the tibiae are of normal shape and size resembling those of *Penicillidia*. In general appearance the species of *Basilia* resemble *Penicillidia* but differ mainly in the possession of two ocelli instead of one.

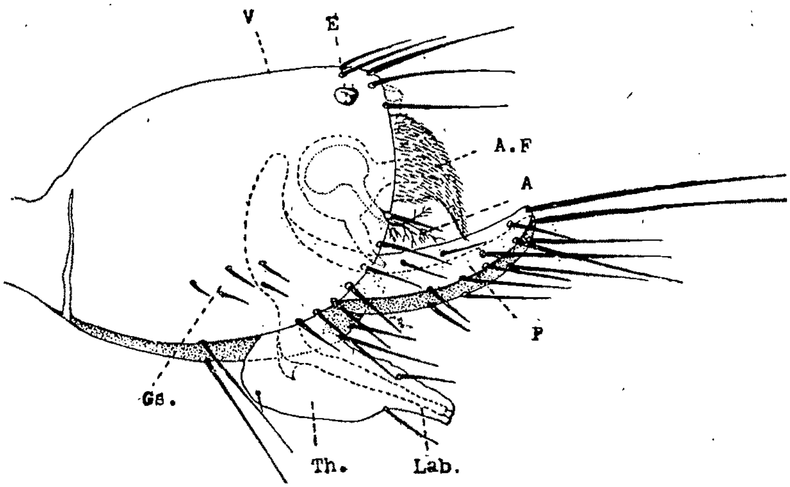


FIG. 55. *Basilia scotti*. Lateral view of head.

7. **Basilia scotti,** sp. n.

(Figs. 55-64)

Only *Basilia nattereri*, *B. eileenae* and *B. bathybothyra* have been recorded from the Old World. Of these, *B. bathybothyra* is known to occur in this country, while *B. nattereri* and *B. eileenae* are recorded from Europe and Ceylon respetively. In this investigation a large amount of material belonging to the genus *Basilia* was collected from Bombay and Hubli in the year 1952 and 1953. On The material differs from *B. nattereri* in possessing tergite 1 with two posterior lobes, each bearing 3-6 long setae and tergite 2 (2-5 fused) in female, heart-shaped, instead of being rectangular. It also differs from *B. eileenae* in having tibia of normal shape and size instead of being laterally compressed. Since Speiser's original description of *B. bathybothyra*, which was latter placed by Scott (1925) under the genus *Penicillidia* as a synonym of *P. fletcheri* var. *pumila*, does not give any valid characters, it is not possible to compare this material with it.

Hence the specimens under discussion belong to a species which is new to science and it is named it as *B. scotti* after Scott of British Museum for his valuable work on Nyeteribiids.

Length 2.6-3.2 mm. in both sexes. Colour yellowish-brown in mounted specimen.

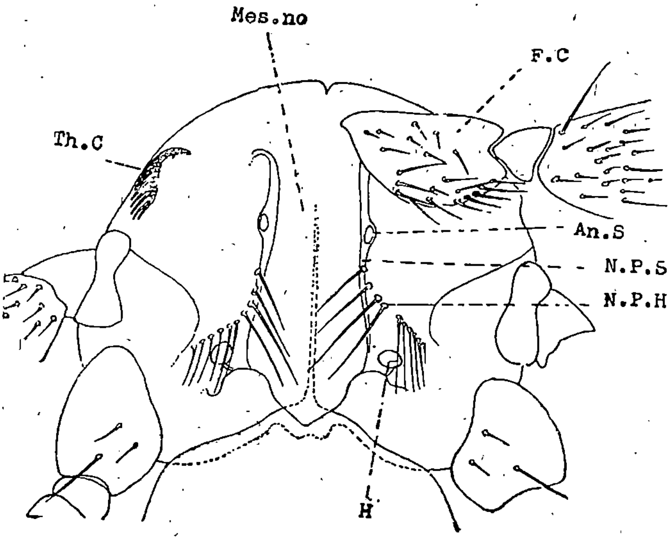


FIG. 56. *Basilia scotti*. Dorsal view of thorax.

Head : Bare except four elongated setae on the vertex in between the eyes and a row of short hairs along the anterior border of the cheeks. Eyes consist of two ocelli with a pigmented base. Genae with 6 short hairs. Palps as in *P. fletcheri*. Labella shorter than theca.

Thorax : Broader than long, measuring 1.1 x 0.68 mm. Ventral surface flat with short hairs. Median sternal suture broken in the middle and impressed posteriorly. Hind margin of thorax with a fringe of 4-6 long setae, interspersed by 2-4 short ones. Dorsal pattern :—Mesonotum broader posteriorly. Anterior spiracles small, round, situated at the posterior limit of insertion of the head. Lateral plate of notopleural sutures broad with a row of 10 hairs. Halteres with a slender pedicel and a rounded knob and exposed. Legs of normal shape and size. Front coxae longer than broad bearing a few short hairs dorsally and short and stiff ones on the outer side of the posterior border. Femur as in *Penicillidia* carry short bristles dorsally as well as near the posterior border. Tibia nearly as long as the femur with long, as well as short hairs on the dorsal surface. Tibial rings absent, but with three rows of long hairs. Metatarsus half as long as tibia.

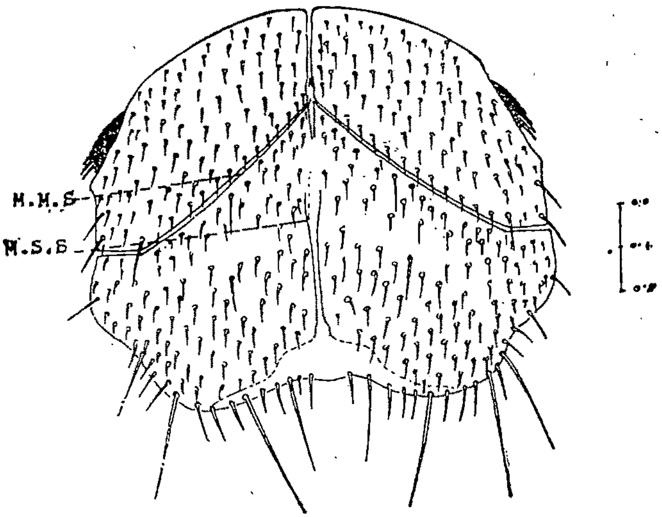


FIG. 57. *Basilia scotti.* Ventral view of thorax.

The comparative lengths of femur & tibia

	Femur	*Tibia*
1st pair of legs	0.88 mm.	5 mm.
2nd pair of legs	1.06 mm.	0.80 mm.
3rd pair of legs.....................	1.10 mm.	0.80 mm.

Abdomen in female : Tergite 1 narrow, pigmented at sides with two posterior processes, each bearing 4-5 long and 2-4 short spines. A group of short setae on the lateral half of the segment. Tergites 2-5 fused into a heart-shaped plate as in *P. fletcheri* and *P. bombayansis* and incompletely divided along the middle into two broad posterior processes bearing 4-5 long setae at the tip and a row of 5-6 short spine-like ones in front of the long setae. A row of 3-5 medium sized hairs at the posterior part of the lateral border of the plate. Short hairs scattered over the lateral part of the surface including the anterior corners and a few short hairs along the middle. Tergite 6 consists of two small rounded plates, each with two long setae extending more than half of the anal segment and 3-4 short ones in front of the long setae. The pale connexivum studded with minute thorn-like setae and smooth medially between the fused tergites 2-5 and the two chitinous plates of tergite 6. Anal segment smooth except few hairs on the posterior half of the surface and long ones at the tip andhi nd end corners.

Sternite 1+2 rounded anteriorly, with the ctenidium of about 55 teeth and the surface covered with short hairs except the anterior middle part. Hind margin of the ctenidium concave in the middle. Sternite 3 membranous and covered with short hairs. From its hind margin arise long setae, extending beyond the hind border of the next segment. Sternite 4 bare, narrow with long setae at the posterior border. Sternites 5 and 6 divided into two elliptical halves each consisting of an oval plate bearing 1-3 rows of short hairs and some longer ones at the sides of the hind margin. Sternite 7 rounded posteriorly with two groups of hairs on the surface except on area in the middle and with short setae along the posterior border. Anal segment conical, pigmented, with a few short hairs at the sides and tip. Its posterior margin strongly emarginate. Dorsal

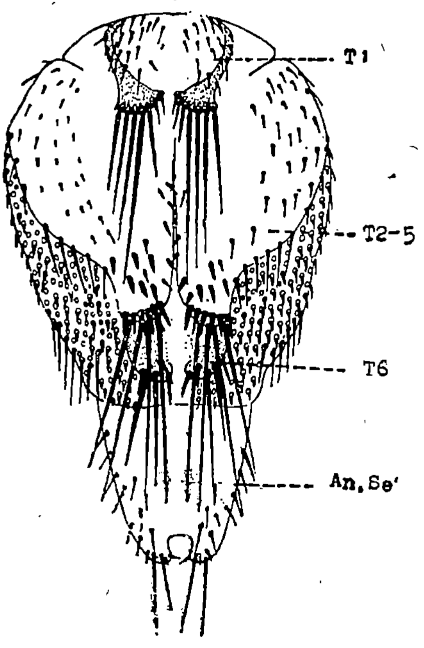


FIG. 58

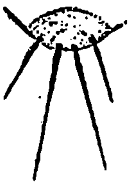


FIG. 60

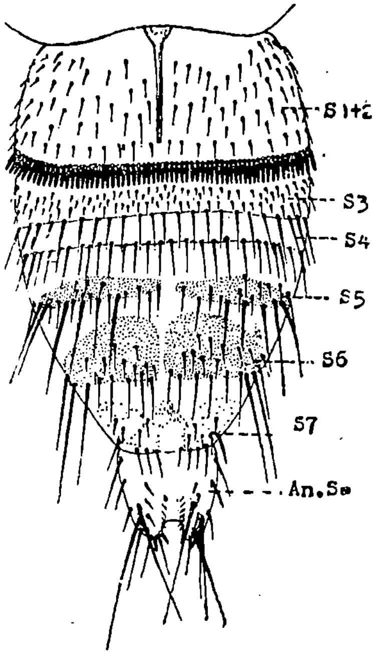


FIG. 59

FIG. 58. *Basilia scotti*. Dorsal view of female abdomen.
FIG. 59. *Basilia scotti*. Ventral view of female abdomen.
FIG. 60. *Basilia scotti*. Genital plate.

genital plate (Fig. 60) small, transversely elongated, oval with 4-5 long hairs, of which two in the middle are longer.

Abdomen in male : Tergite 1 small, roughly trapezoidal, bearing short hairs on the hind margin and a few scattered ones on the surface. Post-spiracular sclerite (Fig. 63) a slightly curved band with two long and five short hairs on the convex side. Tergite 2 large, with the surface almost smooth in the middle and a few short scattered hairs at the sides. Its hind margin acruate, having long setae interspersed with 1-2 short ones, the long setae extending nearly to the middle of the following segment. Of these 4 in the middle are exceptionally long, extending even beyond tergite 5. Tergites 3-6 short, in the form of transverse strips, with fine hairs at the sides and smooth in the middle. The hind margin of these tergites is beset with long and short setae as in tergite 2, but the long setae in the middle of tergites 3 and 4 are not so long as those found on the tergites 2, 5 and 6. Anal segment, conical, with 6-8 erect, short and thick hairs on the posterior half of its surface and 2-4 long setae at the hind corners.

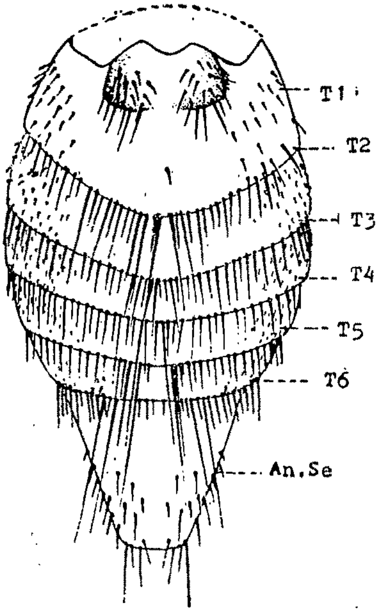


Fig. 61

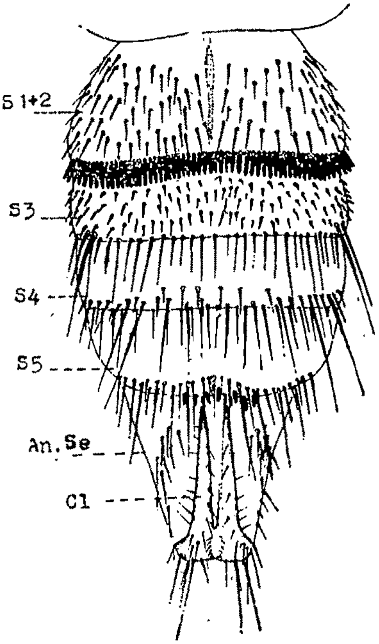


Fig. 62

Fig. 61. *Basilia scotti.* Dorsal view of male abdomen.
Fig. 62. *Basilia scotti.* Ventral view of male abdomen.

Sternite $1+2$ as in female. Sternite 3 narrow, with a row of moderately long and short setae at the hind margin and short hairs on the surface. Sternite 4 narrow, with a row of moderately long and short setae at the hind margin and a single row of short hairs anterior to the hind border. Two to four setae at the sides of the hind margin long and directed outwards. Sternite 5 short, with the posterior border rounded bearing a row of moderately long and short setae, 1-2 at the sides much longer. In addition to these, sternite 5 bears a row 10-12 short dark, thick spines, in the middle of the hind margin and another row of long, slender hairs, continuous with the lateral ones on the hind border. Anal segment with numerous short erect setae at the sides and long ones at the hind margin.

Genitalia (Fig. 64): Basal arc moderately broad and rounded with a pointed process anteriorly. Dorsal hinge of phallobase strongly chitinized and pigmented with a pair of long hairs at the base. Aedeagus short tapering to a point, curved slightly with a membrane distally. Apodome twice longer than aedeagus and expanded distally. Parameres thick, broad, with a rounded tip and a row of 5-6 short hairs on the outer surface and 1-2 short ones on the ventral border. A pair of long hairs between the base of the phallobase and the basal arc. Claspers, short, curved with the arms more or less parallel when in position, tapering to a point, brownish in colour and pigmented dark at the tip. A row of long setae on the outside of the basal half and longer setae near the base.

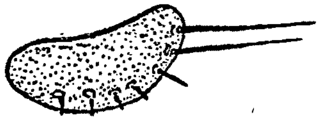


FIG. 63

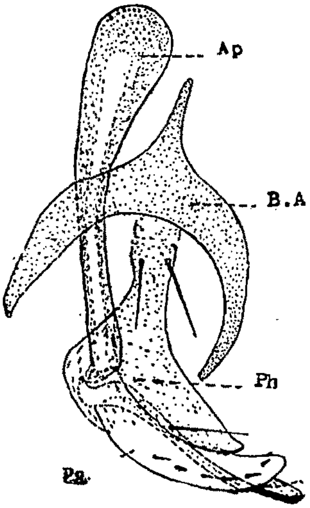


FIG. 64

FIG. 63. *Basilia scotti*. Post-spiracular sclerite.
FIG. 64. *Basilia scotti*. Male genitalia.

Host.—45 females and 39 males from *Pipistrellus ceylonicus chrysothrix* from Carla Caves, Bombay State, July and September, 1953. 20 females and 15 males from house-bats at Hubli in 1952.

Genus **Cyclopodia** Kolenati, 1863

The genus *Cyclopodia* is characterised by eyes with two ocelli and legs with three rings on tibia. The head in the species of this genus is dorso-ventrally compressed excepting *C. roylei*, in which it is laterally compressed. Scott (1917) placed all the species having the head dorso-ventrally compressed into a subgenus *Cyclopodia* and *C. roylei* with the head laterally compressed, in another subgenus *Paracyclopodia*. Out of a dozen species known under this genus four species viz. *C. ferrarii*, *C. roylei*, *C. sykesii* and *C. hopei* have been reported from India. The first two have been obtained from Bombay bats and they have been critically studied in this paper.

8. **Cyclopodia sykesii** Westwood, 1835

(Figs. 65-71)

This is a common parasite found on flying foxes and is reported from different parts of India. Scott (1908) described it briefly pointing out the variations in the abdominal spines, without giving a complete set of figures.

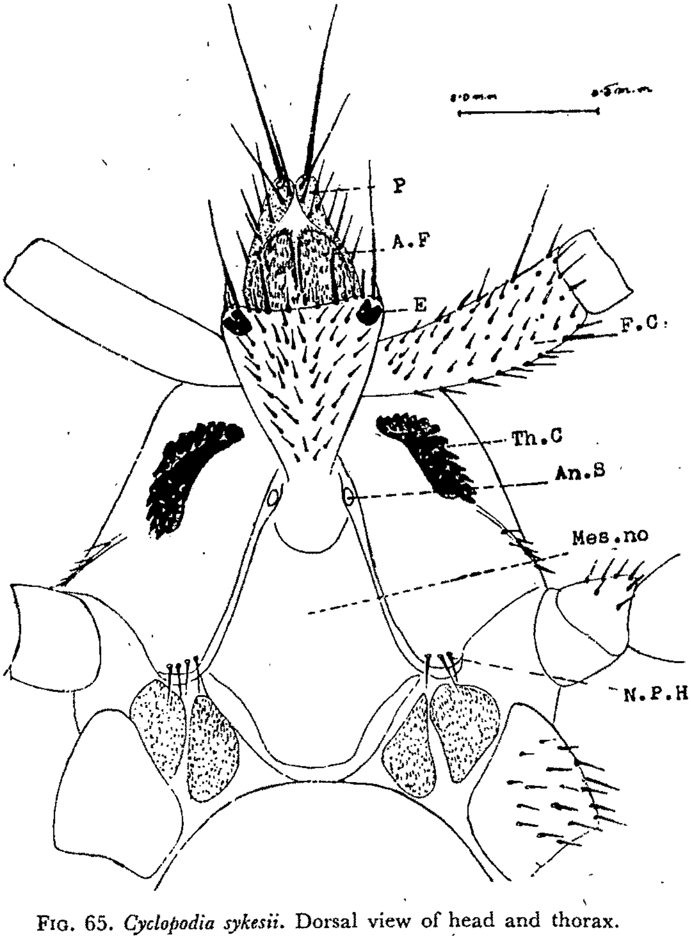


FIG. 65. *Cyclopodia sykesii*. Dorsal view of head and thorax.

The genitalia which has not been studied in the past, described here.

Length 4.8-5.2 mm. *Colour* light brown in mounted slides.

Head : Compressed dorso-ventrally. Ptilinum membranous, partly covering the antennae. Vertex studded with short hairs. A row of short setae with 1-2 long ones along the anterior border of the vertex and cheeks. Fronto-clypeus well developed protruding ahead of the antennae. Eyes big, with two ocelli on a round pigmented base. Palps slender, twisted distally, with two rows of short hairs on the lateral surface and one moderately long at the tip. Labella nearly twice as long as the theca.

Thorax : Almost flat, as long as broad, the anterior border broadly rounded and measures 1.6 -1.8 mm. Ventral surface covered with short hairs. A row of long hairs at the sides and a row of short hairs in the middle of the posterior border. Median sternal suture expanded in the middle and impressed behind. The suture between the meso- and metasternum forms an arch at right angles with the junction of the median sternal suture. Dorsal pattern: Mesonotum membranous and wide posteriorly. Anterior spiracles oval. Lateral plate of the notopleural suture small, with 2-4 short hairs in a transverse line. Halteres covered over by a flap. Legs long and slender. Front coxae much longer than broad and covered with short hairs dorsally. Tibia with three distinct rings bearing long and short hairs on the dorsal and lateral surfaces.

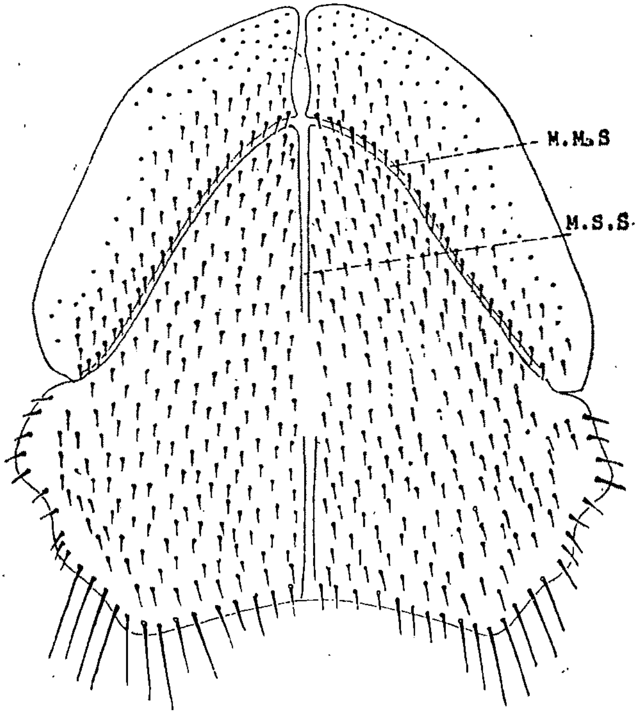


FIG. 66. *Cyclopodia sykesii.* Ventral view of thorax.

Abdomen in female : Tergite 1 small, round without any clear posterior lobes, bearing 8 short spines and the surface covered with short hairs. Tergite 2 highly chitinized, dark brown in colour, bare anteriorly and covered with short hairs posteriorly. Its hind margin almost straight and smooth for the most of its length and oblique or curved at the sides bearing 4-5 long setae. Tergites 3-5 membranous and studded with short spines with a broad base. Four tubercles usually placed at the corners of a small square in the centre of the dorsal surface between the 3rd and 4th spiracles. Sometimes a tubercle may be out of place and the grouping may be irregular. Tergite 6 narrow with numerous long setae. Tergite 7 conical and smooth. Anal segment small, conical, with two lateral plates, separated along the median line and bearing a row of long setae on the inner border.

Sternite 1+2 broad, transversely curved, with about 40 thick and blunt teeth and the surface covered with short hairs and without a median line. Sternites 3-6 membranous and covered with short hairs anteriorly and a little longer ones posteriorly. Ventral genital plate H-shaped bearing a row of short pigmented spines so as to cover the genital opening. Dorsal genital plate absent. Dorsal lip of the genital opening formed by the post-anal sclerite bearing no hairs.

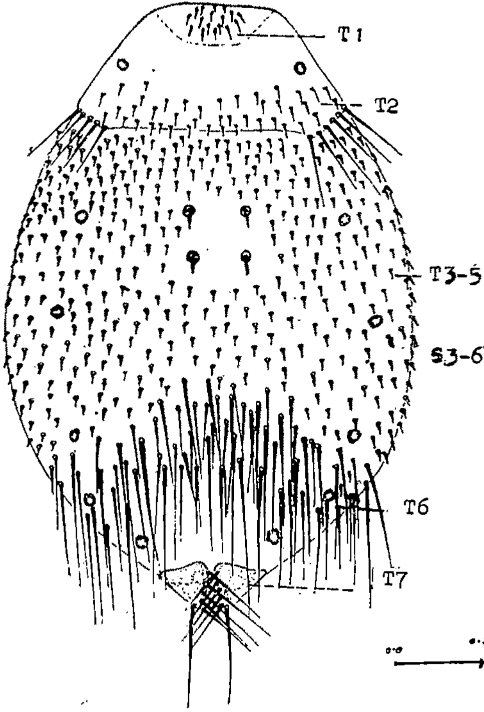


FIG. 67

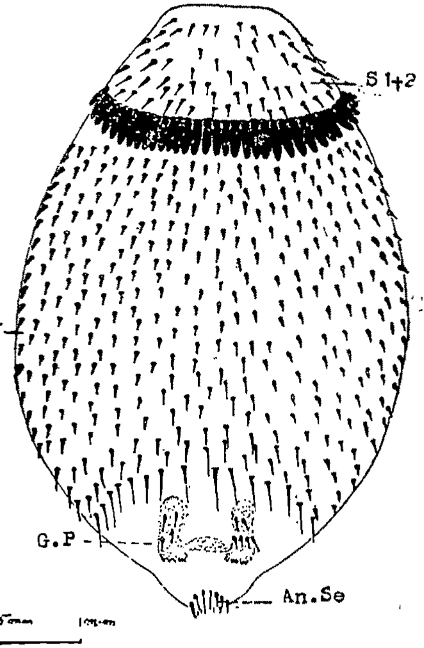


FIG. 68

FIG. 67. *Cyclopodia sykessi* Dorsal view of female abdomen. FIG. 68. Ventral view of female abdomen.

Abdomen in male Tergite 1 small, with short hairs as in female. Tergite 2 broad, with the hind border convex having 4-6 moderately long setae at the sides and bare medially. Its surface covered with 2-3 rows of short hairs anterior to the hind border. Tergite 3 broad, with short hairs and a row of short and long setae having a gap in the middle at the posterior border. Tergite 4 similarly covered with short hairs on its surface and along the hind border but the hairs on the surface sparse. Tergite 5 narrow, bare, with a row of short hairs at the posterior border having a middle third of its length without setae but with very slender hairs. Tergite 6 similar to tergite 5. Anal segment elongated, conical, bearing a few scattered hairs in the middle third portion of its surface and 2-4 long ones at the hind end corners.

Sternite 1+2 as in female. Sternite 3 narrow, covered with short hairs on the surface. A row of fine hairs in the middle and 4-6 long setae at the sides of the hind border. Sternite 4 broad and covered with short hairs. Its hind margin with a row of short hairs in the middle and longer ones at the sides. Sternite 5 with a few scattered hairs on the surface. Its posterior margin rounded, bearing a row of fine hairs and 5-7 short, thick spines in the middle. In addition,

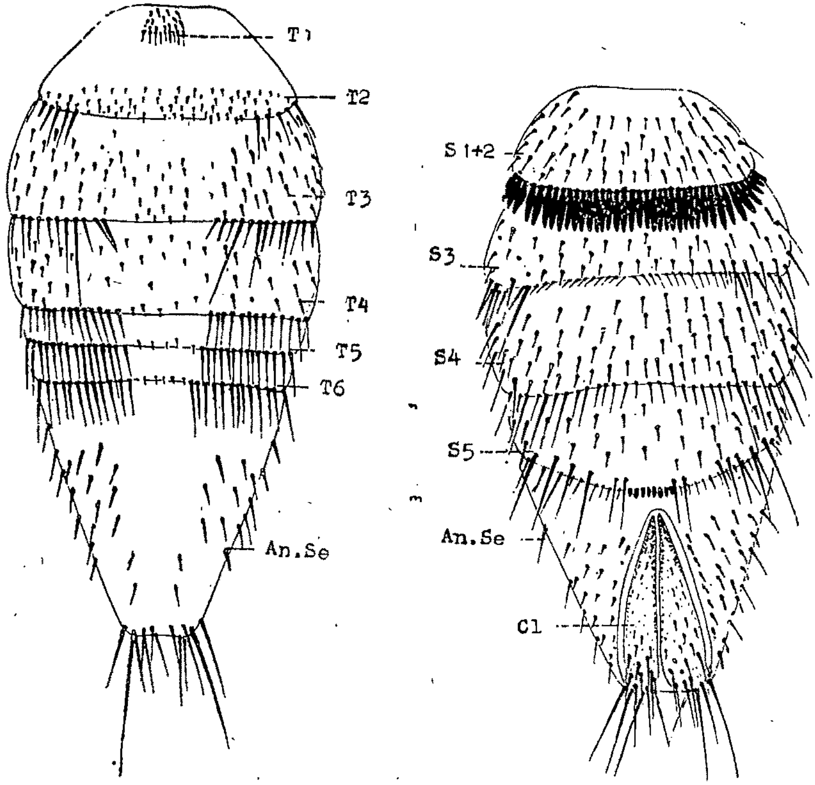


FIG. 69 FIG. 70

FIG. 69. *Cyclopodia sykesii* Dorsal view of male abdomen.
FIG. 70. *Cyclopodia sykesii* Ventral view of male abdomen.

another row of long setae anterior to the hind border. Anal segment conical and covered with short hairs at the sides.

Genital apparatus (Fig. 71): Phallobase strongly developed with a dorsal sclerotized plate anteriorly. Base of phallobase with 8-12 long slender hairs dorsally. Parameres reduced to a small elongated plate bearing a few minute hairs and lying at the opening of the phallobase. Aedeagus a membranous tube, with a pointed rod in it. Apodeme long, rod-like without any expansion distally and enclosed in a pouch.

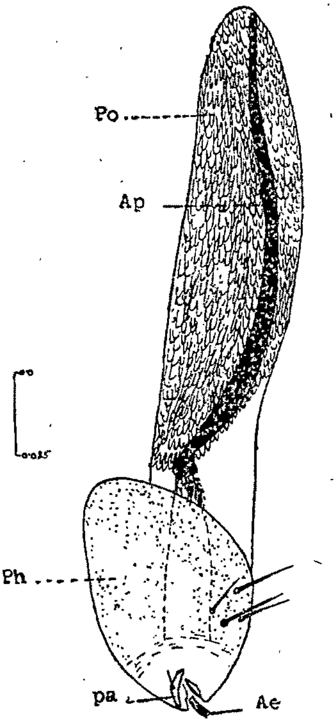


FIG. 71. *Cyclopodia sykesii.* Male genitalia.

Host : 7 females and 5 males from *Pteropus giganteus giganteus,* Victoria Gardens, Feb. 1952. A few specimens from Flyingfoxes, Lucknow, in 1946.

The past record is from *Pteropus giganteus leucocephalus,* Orissa, 1911 and also from Flyingfoxes, Madras 1908. The general distribution is Burma, Ceylon Maldives and Judeae.

9. **Cyclopodia ferrarii** Rondani, 1878

(Figs. 72-77)

This was first described by Rondani (1878), from a single male specimen from Java and subsequently Speiser (1901) described a female from Burma. Scott (1914) described it in short from Ceylon, modifying the earlier descriptions.

Length 2.6-3 mm. in both sexes. *Colour* yellowish-brown to dark-brown in mounted slides.

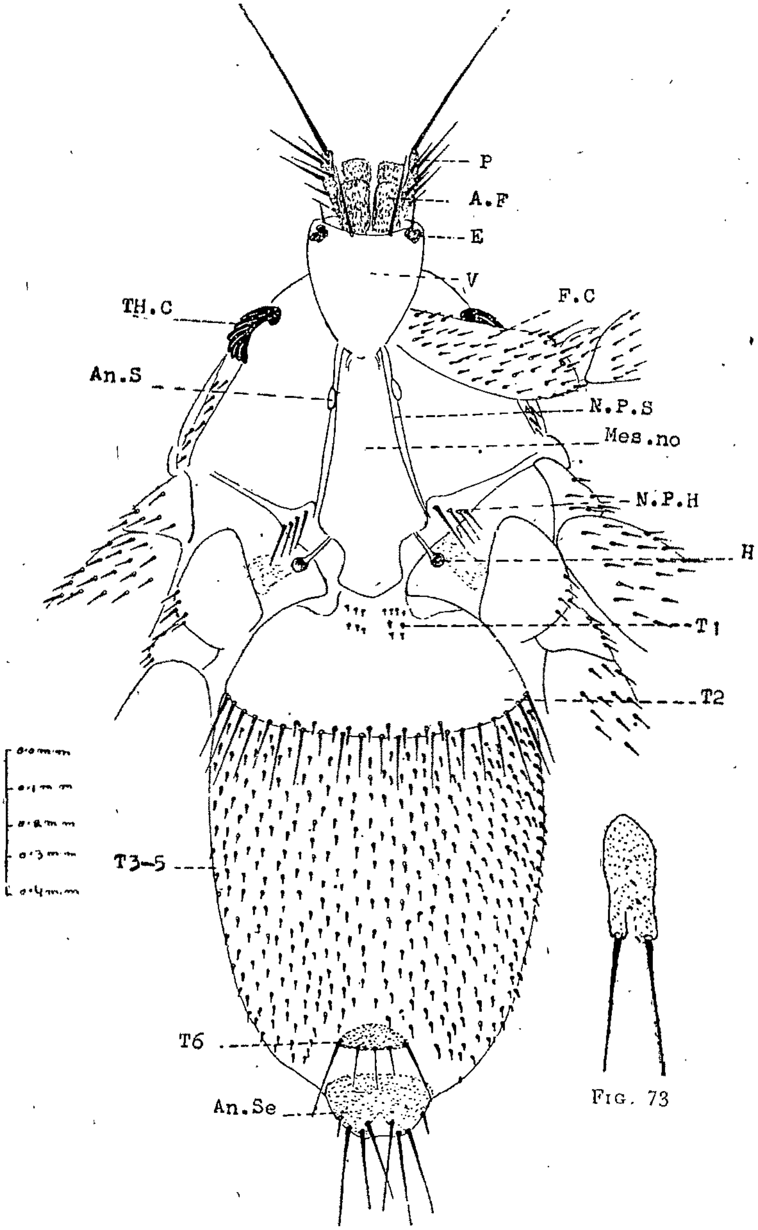


FIG. 72

FIG. 73

FIG. 72. *Cyclopodia ferrarii* Dorsal view of head, thorax and abdomen female. FIG. 73. Dorsal genital plate.

Head : Compressed dorso-ventrally as in *C. sykesii* but different from it in not being so much chitinized and the vertex between the eyes smooth. A single seta on the anterior margin of the cheeks. Genae without hairs. Eyes consist of two ocelli mounted on a black pigmented base. Ventrally, anterior margin of post-genae with 4-5 pairs of long setae along the junction with the membranous area. Palps with moderately long hairs on the lateral surface and a very long one at the tip. Theca broader than long. Labella twice as long as the theca.

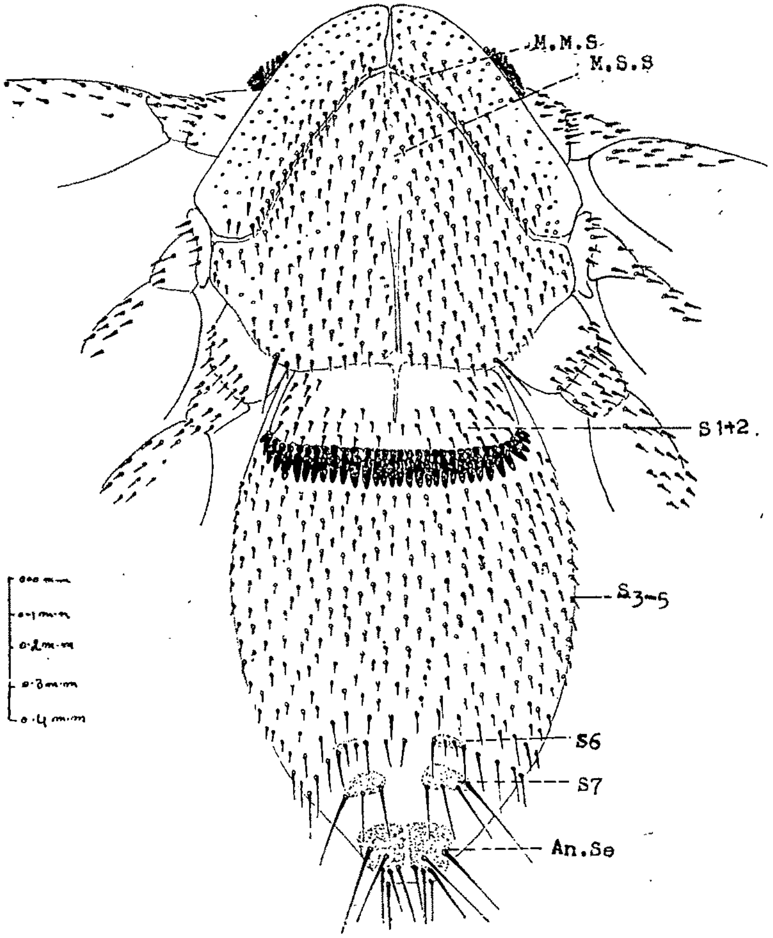


FIG. 74. *Cyclopodia ferrarii.* Ventral view of head, thorax and abdomen female.

Thorax : Longer than broad, measuring 1.3 × 1.0 mm. Ventrally, surface studded with short hairs. Median sternal suture expanded in the middle and impressed behind. From the hind border arise hairs of the same length as found on the ventral surface but of these 1-2 at the corners long. Mesonotum broad posteriorly with the notopleural sutures nearly straight. Anterior spiracles oval, placed behind the articulation of the head to the thorax. Mesopleural suture straight. Mesopleural plate elongated bearing 4-5 long notopleural hairs placed obliquely and transversely to the notopleural sutures. Halteres small, and not covered by a flap. Legs strongly built. First pair of coxae, 3 times longer than broad with the dorsal surface studded with short hairs and the ventral surface smooth. Femur strong, with short hairs dorsally and longer ones towards the posterior border and a clear ring in the middle. Tibia as long as femur covered with moderately long hairs dorsally as well as ventrally and 1-2 long setae near the posterior border. Tibia with 3 distinct rings.

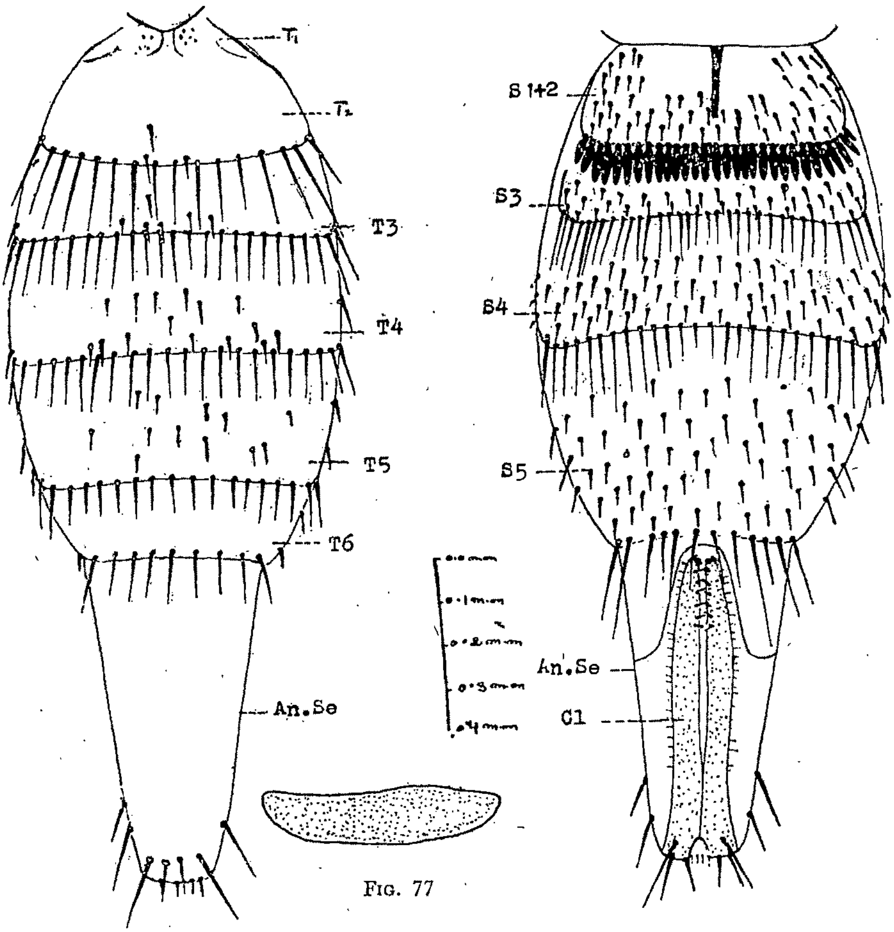


FIG. 77

FIG. 75. *Cyclopodia ferrarii* Dorsal view of male abdomen. FIG. 76. Ventral view of male abdomen. FIG. 77. Post-spiracular sclerite.

Abdomen in female : Tergite 1 small, with two groups of few short hairs at the sides of the surface. Tergite 2 broad, smooth, bearing a row of long setae at the hind border and still longer ones at the sides. Four to eight short hairs quite close to the hind border. Tergites 3-5 fused, membranous, covered with short hairs and with a short median, transversely elongated plate bearing a row of 4-5 long setae at its hind border. Anal segment conical, with a strong setae in the posterior half and a few long ones at the hind end corners.

Sternite 1+2 broad, with about 35 strong teeth and the surface covered with short hairs, except an area behind the thorax. Its median longitudinal line impressed in the middle and not extending to the hind border. Sternites 3-5 fused, membranous, bearing a little longer hairs than those found dorsally. A row of long setae at the hind border. Sternite 6 with two small chitinous plates, separated from each other by a wide gap. Each plate bears 4 long setae, of which two in the middle smaller. Sternite 7 with two chitinous plates, each bearing a row of 3-4 long setae at the hind border. Anal segment consists of two broad plates studded with long setae in the posterior half. Dorsal genital plate (Fig. 73) poorly chitinized bearing 2 long hairs posteriorly.

Abdomen in male : Tergite 1 small, with a few hairs on its surface. Post-spiracular sclerite (Fig. 77) without any hairs. Tergite 2 broad, bearing a row of long setae at the posterior border. Tergites 3-5 narrow, with the surface covered with a few scattered setae in the middle and a row of long setae at the hind border. Tergite 6 bare, with a row of long setae at the posterior border. Anal segment much elongated longitudinally, smooth, having a few short hairs near and on the posterior border.

Sternite 1+2 as in female. Sternites 3 and 4 studded with short hairs and with a row of moderately long setae at their posterior border. Sternite 5 long, conical, mostly covered with short setae and long ones on the hind margin.

Genitalia : Similar to that of *C. sykesii* but differing from it in the absence of a pouch. Dorsal plate of phallobase triangular with a process at its anterior end. Parameres reduced to small plates. Aedeagus also membranous as in *E. hyrtlii orientalis* and the pouch lined with recurved spines. Apodeme long, 1½ times as long as the aedeagus.

Host. 14 females and 8 males *Cynopterus sphinx sphinx*, Bombay Veterinary College Compound, October, 1953.

Scott (1925) recorded this species from *C. marginatus* Calcutta Museum Building, 1914 and from Ceylon on *C. brachyotis ceylonicus*, 1923. The general distribution is Java, Sumatra, Burma, Ceylon and India.

Genus **Tripselia** Scott, 1917

Scott (1917) created a genus *Tripselia* for Nycteribiids possessing tibia with 3 rings as in the genus *Cyclopodia*, but the head without eyes. Only one species is known under this genus.

10. **Tripselia amiculata** Speiser, 1907.

(Figs. 78-86)

This species was described by Speiser (1907) on *Taphozous longimanus* from Calcutta. Scott (1917) expressed his opinion that *Tripselia fryeri* which was described by him in 1914 from Assumption Island, might prove identical with *Tripselia amiculata.* Subsequently, in 1925, he stated that specimens described as *T. fryeri* have only 3 bristles, rather long and wide apart, on each lateral margin of tergite 2 of female while in *T. amiculata* these bristles are 4 in number, on each side and a little shorter.

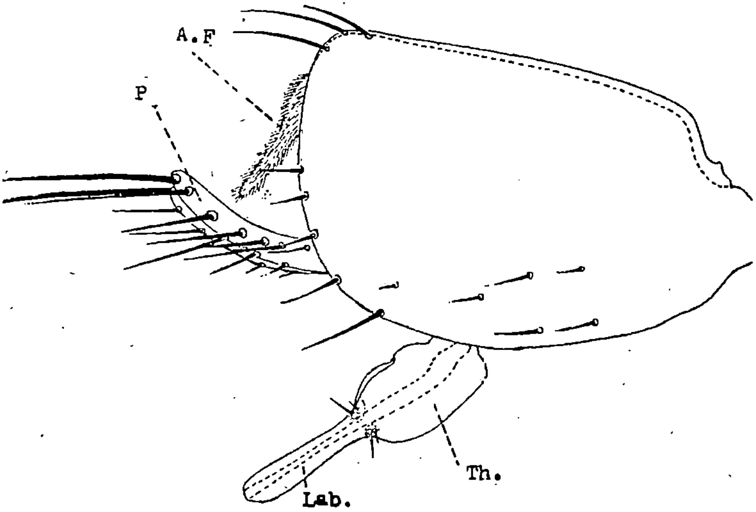


FIG. 78. *Tripselia amiculata* Lateral view of head.

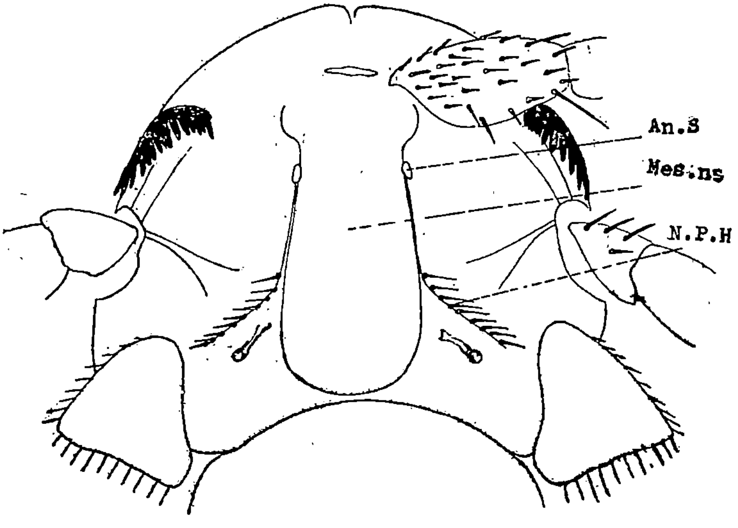


FIG. 79. *Tripselia amiculata.* Dorsal view of thorax.

In the course of this study, half a dozen specimens of *T. amiculata* were obtained from Bombay as well as from Hubli. The examination of the material shows that some specimens have three and others four setae, either long or short, on each lateral margin of tergite 2-5 of female. This tends to show that the two species *T. fryeri* and *T. amiculata* may be identical and it can be further confirmed by working out the genitalia of *T. fryeri* from Assumption Island also.

Since the original description of this species by Speiser (1907) does not give full details, *T. amiculata* is redescribed here with a number of figures and the genitalia is also described for the first time.

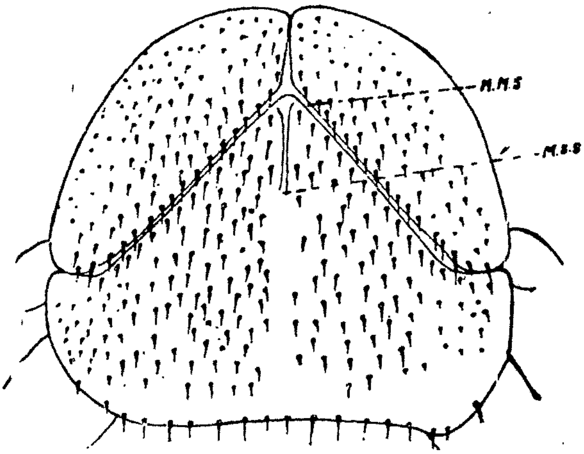


Fig. 80. *Tripselia amiculata.* Ventral view of thorax.

Length: 2.0-2.2 mm. in both sexes. *Colour* yellowish-brown in mounted sides.

Head: Longer than broad with the vertex in straight line along its longitudinal axis. Ptilinum short. Vertex with 4 long setae at the anterior margin. A row of moderately long setae along the anterior margin of the cheeks. Eyes absent. Genae with 6 short hairs. Palps sparsely covered with long setae on the lateral surface and two long ones at the tip. Labella longer than theca.

Thorax : Wider than long, measuring 0.8 × 1.0 mm. Ventrally, surface nearly flat, covered with short hairs, the anterior border comparatively more rounded and bears hairs of equal lengths. Median sternal suture flattened in the middle and much impressed behind. Mesonotum broader posteriorly and the anterior spiracles small and oval. Lateral plate of notopleural suture not so broad, bearing 8-12 short notopleural hairs in a more or less straight line, beginning a little away from the anterior spiracles. Halteres small with a circular knob and exposed. Legs slender, long, with lateral expansion as in *Listropodia.* Coxai twice longer than broad and covered with short hairs. Femur and tibia of all legs sparsely covered with short hairs and 2-3 long ones on the dorsal surface of the tibia. Tibia with 3 rings and marginal setae.

Abodmen in female: Tergite 1 small, narrow, broader behind, with two posterior processes each bearing 5-6 long setae and 2-4 short ones in front of long setae. A group of short hairs on the surface of each lobe. Tergites 2-5 fused, heart-shaped as in *Basilia* and *Panicillidia* with two broad posterior dagger-like processes. On the inner margin of each process arise 4-5 short setae and 2-3 long ones extending upto the posterior end of the abdomen. A row of 4 long setae on the posterior half of the lateral border of the plate. Surface witha few short hairs scattered on the lateral part and along the median line. Tergite 6 with two small, strongly chitinized yellowish plates, having a slightly rounded hind margin bearing 6 long setae, 3 on either side, separated by a median interval.

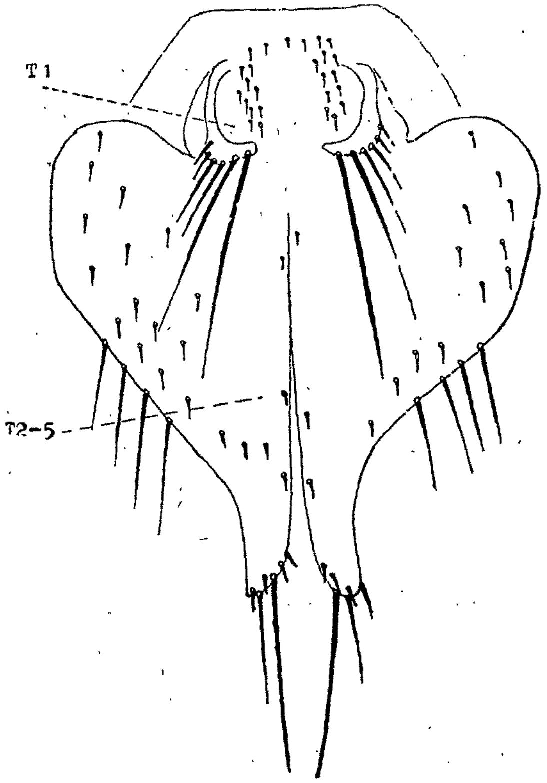


Fig. 81. *Tripselia amiculata.* Tergites 1, 2-5 (fused) female.

Sides of the abdomen covered with short hairs. Anal segment short, bare, tapering posteriorly, with 1-2 short hairs at either side and long and short setae at each hind corners.

Sternite 1+2 rounded anteriorly with a ctenidium of 40-45 long and pointed teeth. Surface with several irregular rows of short hairs, rather long and directed outwards at the sides and smooth towards the base. Sternite 3 with uniform rows of short hairs, becoming slightly longer posteriorly. Its hind border indicated by a row of long and short setae with longer ones at the sides. Sternite 4 with the surface bare and a row of setae at the posterior margin as in sternite 3. Sternite 5 with two poorly chitinized, elongated plates, each bearing short and long setae continuous with the setae on the hind border. Sternite 6 with two plates, separated in the middle, by a narrow space, each plate having a row of short hairs on the surface and a row of long and short setae at the posterior border. Sternite 7 roughly trapezoidal with hind angles much rounded and divided by a narrow pale area into two transverse series of hairs. A row of 10-12 long setae at its hind border. Dorsal genital plate (Fig. 82) small with the anterior border convex and the posterior border straight bearing 4 sufficiently long hairs. Its surface bears a few short hairs. Ventral genital plate absent.

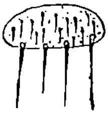


Fig. 82

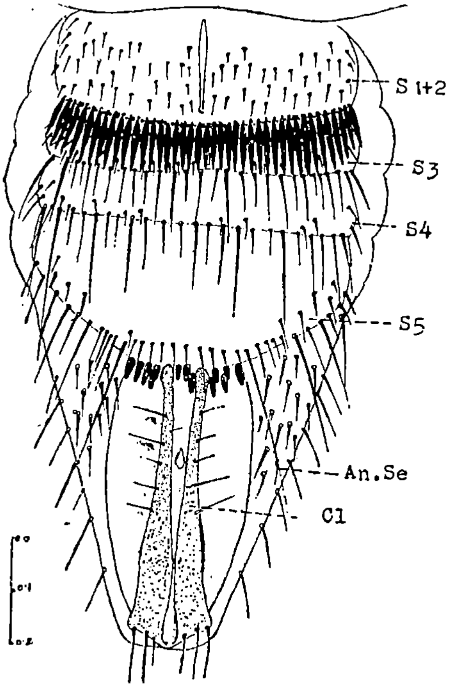


Fig. 83

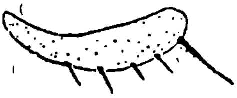


Fig. 84

Fig. 82. *Tripselia amiculata.* Dorsal genital plate.
Fig. 83. *Tripselia amiculata.* Ventral view of male abdomen.
Fig. 84. *Tripsclia amiculata.* Post-spiracular sclerite.

Abdomen in male :- Tergite 1 small, with a few short hairs on the surface, the posterior row indicating the hind border. Post-spiracular sclerite (Fig. 84) crescent-shaped, with 5 short hairs on the convex side. Tergite 2 with numerous short hairs at the sides and middle of the surface. Tergites 3 and 4 with the surface having a few scattered hairs in the middle and a row of long and short setae rather spaced-out at the hind margin as in tergite 2. Tergites 5 and 6 narrow, with a row of short and long setae at the posterior border. Surface of the tergite 5 bears 5-8 short hairs across the middle and that of tergite 6 with 1-2 short hairs at the sides. Anal segment long, conical, with a few scattered hairs in the posterior half of the surface and 2-4 long ones at the hind corners. Some setae in the middle of hind border of each tergites usually longer and directed outwards.

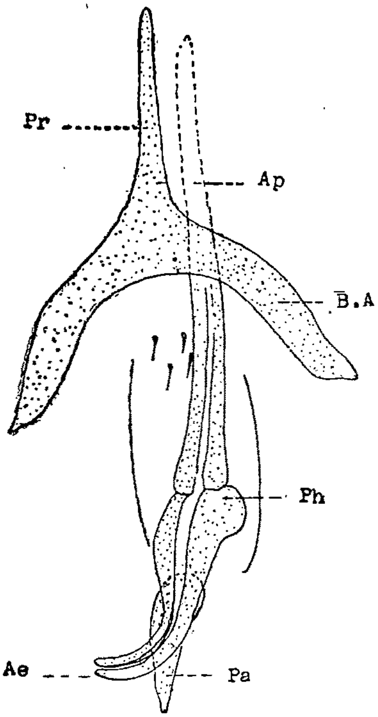


FIG. 85. *Tripselia amiculata* Male genitalia.

Sternite 1+2 as in female. Sternite 3 narrow, with 2-3 rows of short hairs on its surface and a row of long and short ones at the posterior border. Sternite 4 bare except a few scattered hairs anterior to the hind border bearing a row of long and short setae. Sternite 5 acruate, with a row of setae as in sternite 4, along the hind border. Eight to twelve short, dark, thick spines and a row of slender hairs in the middle of hind border. A few scattered short hairs at the sides. Anal segment rather densely covered with short hairs.

Genitalia (Fig. 85-86) : Basal arc broad, rounded with a prominant projection in front. Claspers long tapering from base to apex, pigmented for the most of its length, with parallel arms, each arm bearing a row of slender hairs along the inner border. Aedeagus slender, long, curved, membranous and rounded distally. Apodeme twice longer than aedeagus, without any conspicuous expanded portion at the apex. Parameres short, bare and united. Four long hairs between the base of the phallobase and the basal arc.

Host : 2 males and 4 females from *Taphozous longimanus* at Bombay and Hubli 1953.

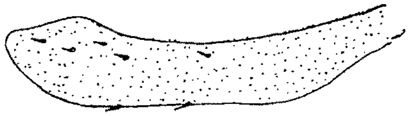


FIG. 86. *Tripselia amiculata* Lateral view of paramere.

Scott's (1925) type material of this species was obtained from *T. longimanus* at Calcutta. It has also been recorded from *Saccolaimus saccolaimus* at Ceylon.

Genus **Eucampsipoda** Kolenati, 1857

The genus *Eucampsipoda* resembles the genus *Cyclopodia* but differs from it in the structure of the eye, the number of tibial rings and the genitalia. Only three species and one subspecies viz. *E. hyrtlii*, *E. hyrtlii orientalis*, *E. aegyptica* and *E. philippinensis* are known so far. Of these *E. hyrtlii orientalis* is found in India.

11. **Eucampsipoda hyrtlii orientalis** n. subsp.

(Figs. 87-94)

Kolenati (1856) briefly described *E. hyrtlii* from *Rousettus aegypticus* from Egypt. Scott (1914), redescribed the male and female from Ceylon and subse-

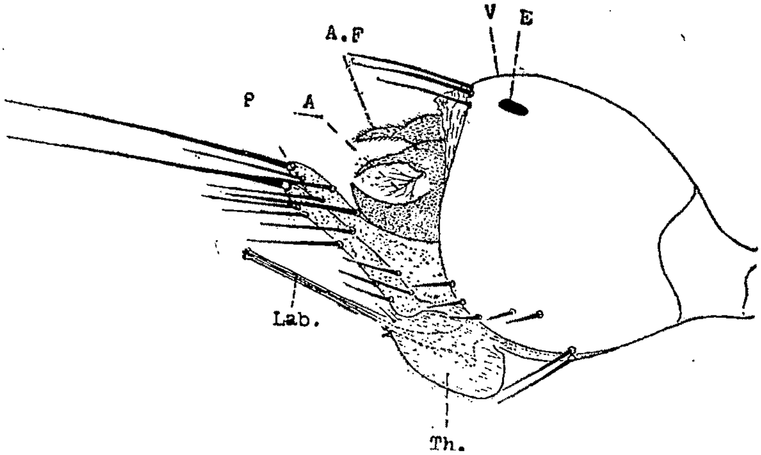


FIG. 87. *Eucampsipodia hystli orientadis.* Lateral view of head.

quently reported it from Orissa. Bal and Ahmed (1949) recorded it for the first time from Bombay State. Theodor and Moscona (1954) redescribed it along with genitalia from Palestine.

Many specimens of this species were obtained from *Rousettus leschenaulti*, at Bombay, during 1952 and 1953. On their close examination, it was found that they differ from *E. hyrtlii* of Palestine as under:-

(*i*) The Bombay specimens have only two groups of 3-6 long setae, each group separated bya small setose area while the Palestine specimens as described, have two more additional groups of short setae, situated anterior to the two groups of longer setae separated by a smooth area and

(*ii*) the two ventral genital plates in Bombay specimens bear 5 short peg-like spines of equal length and are not much elongated. In Palestine material the genital plates carry 6 spines, of which those at the sides are always longer and the plates are much elongated.

Hence the material under discussion has been put under a separate subspecies—*E. hyrtli orientalis.*

Length 2.48 - 2.80 mm. in both sexes.

Head : Short, not as long as in other genera of Nycteribiids and roughly funnel-shaped. Eyes represented by a black empty concavity without any ocellus in them. Vertex with two pairs of moderately long setae at the junction with the ptilinum. Four to five long setae along the anterior margin of the head. Genae bare. Palps thick at base and tapering towards the apex bearing long setae. Labella as long as or longer than theca.

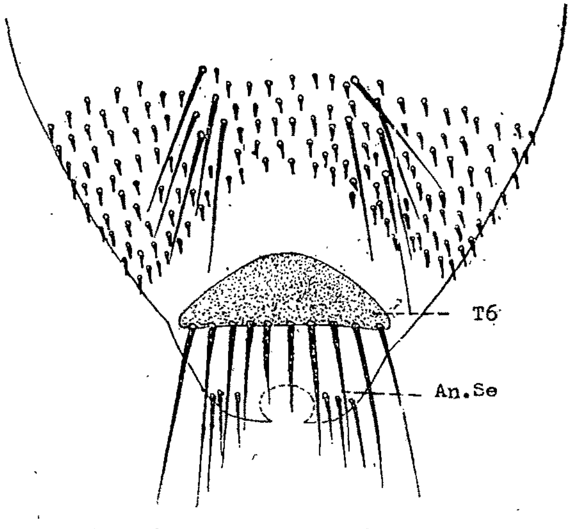


FIG. 88. *Eucampsipoda hyrtlii orientalis.* Dorsal view of postabdomen of famle.

Thorax : Roughly pentagonal. Median sternal suture narrow, well-marked except in the centre. Oblique sutures meet the median sternal suture at right angles. Ventral surface studded with short hairs and still smaller ones anterior to the oblique sutures. Mesonotum wider posteriorly, with the anterior spiracles elliptical and situated near the anterior third of the thorax. Mesopleural suture short, broad at base and tapers laterally. Lateral plate of the mesopleural suture absent bearing one short and long hairs. Tibia long and cylindrical, slightly flattened, as long as femur in the fore-legs or slightly shorter than the femur in the mid and hind-legs. Tibia with 2 rings and one short and three long hairs on the outer surface.

Abdomen in female : Tergite 1 rounded (which consists of tergites 1 and 2 fused together), roughly rectangular, with a row of moderately long setae at the posterior margin and a row of few short hairs anterior to the hind border. Two groups of 4-5 short hairs near the base. Tergites 3-5 fused into a membranous area, without showing any segmentation and studded with short, spine-like hairs. In the middle, two groups of 3-6 long setae, each separated by a small setose area. In Palestine specimens two more groups of short setae anterior to the groups of long ones, separated from each other by a bare area. Tergite 6 crescent-shaped, three times broader than long bearing a row of 12-14 long setae usually of uniform length at the posterior border, sometimes separated in the middle. Anal segment short with a few setae at the apex.

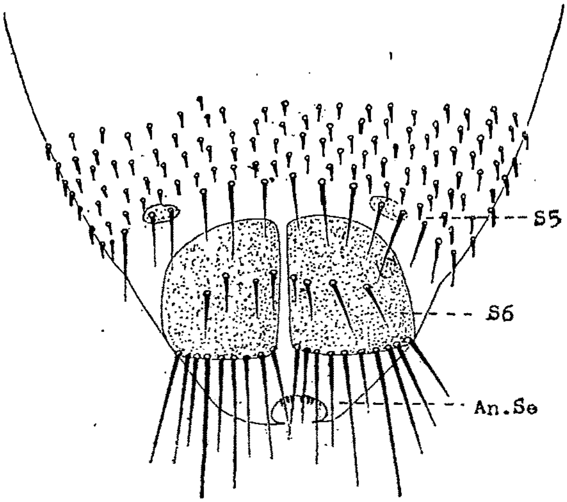


FIG. 89. *Eucampsipoda hyrtlii orientalis*. Ventral view of postabdomen of female.

Sternite 1+2 rectangular with a ctenidium of 32-36 teeth, two rows of short hairs and a few more at the sides anterior to the posterior margin. Rest of the abdomen membranous, covered with short, spine-like hairs. Sternite 3 demarkated by a row of little longer setae with two long ones at the posterior margin. Its surface indicated by short spine-like setae and 4 long ones mixed in them. Then followed by a narrow, bare strip. Sternite 4 consists of 2-3 rows of short spines and a row of moderately long setae at the hind border. Sternite 5 studded with 2 rows of short spines, longer than those found on the previous sternite. Its posterior row of setae long with two small lateral sclerites bearing one short and long setae. Sternite 6 divided into two roughly triangular plates having a row of long setae, alternating with 4-5 shorter setae at the hind margin and a transverse row of 3-4 short setae across the middle. Ventral genital plate (Fig. 90) divided into two leaf-shaped halves, each bearing five short, thick, peg-like spines at the inner border. In *E. hyrilii* from Palestine ventral plates thin bearing 6 short, peg-like spines, the one at the sides always longer. Dorsal genital plate broad and thin.

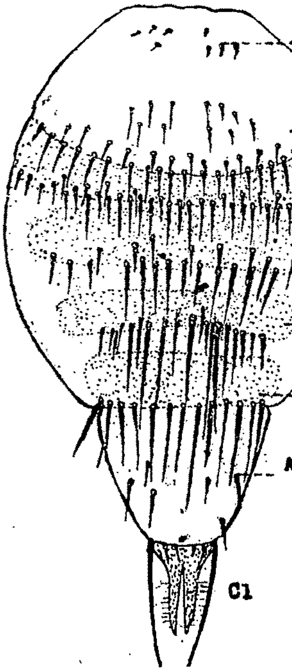


FIG. 91

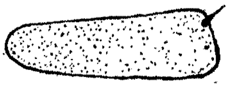


FIG. 93

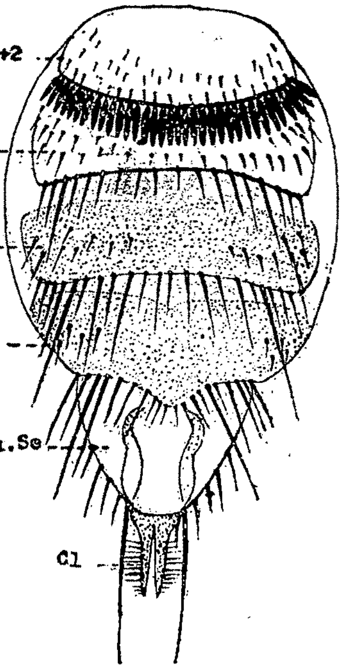


FIG. 92

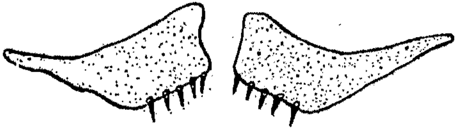


FIG. 90

FIG. 90. *Eucampsipoda hystlii* orientalis. Ventral genital plate. FIG. 91. Dorsal view of male abdomen. FIG. 92. Ventral view of male abdomen. FIG. 93. Post-spiracular sclerite.

Abdomen in male : Tergite 1 and 2 as in female. Post-spiracular sclerite (Fig. 93) with one short seta at the broader end. Tergites 3-6 narrow, with a row of long and short setae at the posterior border. Surface of tergites 3,4 and 5 smooth except a few scattered setae near the posterior border. Tergite 6 smooth and shorter than tergite 5. Anal segment conical with very short hairs in the middle and 2-4 long ones at the hind corners.

Sternite 1+2 as in female. Sternite 3 narrow, with rather short setae at the hind margin and sparsely covered with short hairs. Sternite 4 similar to 3rd but some of the setae at the sides of the posterior border longer still. Its surface bears a single row of short setae, broken in the middle, across the centre of the disc. Sternite 5 long and produced into a rounded projection in the middle of its hind margin. A row of long and short setae, with a few slender hairs in the middle of the projection at the posterior border. Three to five short hairs at the sides of the surface. Anterior margin of sternite 4 and 5 indented in the middle. Anal segment conical and bare.

Genitalia (Fig. 94) : Basal arc with a long process. Aedeagus cylindrical with an oblique posterior opening. Parameres small, triangular with a single short hair in the middle on the convex side. Apodeme slightly longer than aedeagus, with a short collar at the junction with the aedeagus. Endophallus covered with short teeth. Claspers long, straight, slightly different from *E. hyrtlii*, in having long hairs in addition to thick, peg-like spines near the tip.

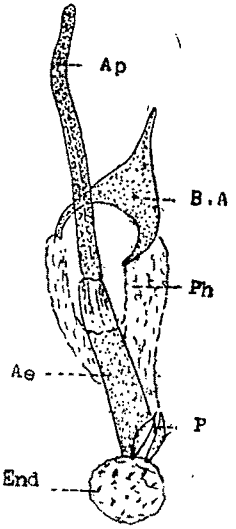


FIG. 94. *Eucampsipoda hyrtlii orientalis.* Male genitalia.

Host. 40 females and 27 males from *Rousettus leschenaulti* Desm. Jogeshwari and Elephanta Caves, Bombay, 1952-54.

Scott (1925) has recorded *E. hyrtlii* whic his probably *E. hyrtlii orientalis* from Orissa and Suju Caves, Assam.

(*iv*). *Geographical distribution of Nycteribiids*

The distribution of parasites over the surface of earth depends upon two factors viz.

(a) the presence of a suitable host and
(b) the habits and environmental conditions.

The parasite whose development does not require any intermediate host is generally found everywhere, provided the environmental conditions are favourable. With the introduction of intermediate host, the distribution of a parasite is restricted to a place where the intermediate host is found.

The geographical distribution of Nycteribiids has been discussed briefly by Speiser (1907-1908). As stated by him, Nycteribiids appear to be peculiar to the Old World, particularly the land bordering the Indian Ocean. This is quite evident from the numerous records made from time to time from this area. It is believed that *Basilia* is one of the most primitive and has migrated to many modifications, while in the Old World they have retained their primitive New World, undergoing characters. Some species are restricted to a particular place while others are distributed over many parts of the world. The Oriental and Australian Species together amount to six times the number of the New World. From geographical point of view the Nycteribiids of the Old World may be divided into the following groups:—

(1). *Species belonging to Oriental Region*

Scott (1925) subdivided Nycteribiids belonging to Oriental Region into two groups:—

(*i*) Species wide-spread in the east and
(*ii*) Species known exclusively from India, Ceylon and Burma.

Such a division in our opinion is not admissible at this stage, as most of the species recorded in the eastern part of the Oriental Region are also reported from the western part. *Penicillidia jenynsi* var. *indica*, *P. fletcheri*, *P. bombayansis*, *Nycteribia euxesta*, *N. allotopa*, *N. parvula*, *N. annandalei*, *Cyclopodia sykesii*, *C. ferrarii*, *C. roylei*, *Basilia eileenae* and *B. scotti* are the species of the Oriental Region and all except *B. bombayansis* and *Basilia scotti* at present seems widely distributed. *B. bathybothyra* has not been thoroughly known and hence it is not taken into consideration while discussing its distribution. *P. peali* and *N. euxesta* have once been reported from Assam and Orissa in India.

(2). *Species of the Palaearctic Region*

Usually the members of the genera *Nycteribia*, *Penicillidia* and *Basilia* are found in this region. *Nycteribia pedicularia*, *N. latreilli*, *N. kolenati*, *N. schmidlii*, *N. vexata*, *N. biarticulata*, *N. biloba*, *N. integra*, *Basilia nattereri*, *B. bathybothyra daganiae*, *Penicillidia dufouri*, *P. conspicua* and *E. hyrtlii* are recorded from Palaearctic Region. Of these *N. vexata*, *P. dufouri* have been reported from the upper Himalayas, which is considered as a part of Palaearctic Region.

(3). *Species occuring in both African, Palaearctic and Oriental Regions.*

Eucampsipoda hyrtlii has been reported from all the three regions while *Tripselia amiculata* is known to occur in the African and Oriental Regions.

In the course of study of Nycteribiids from Bombay state, considerable host-parasite specificity was found. The abundance of these parasites on a particular host depends upon the environmental conditions, suitability of the breeding places, population of the host and the period of roosting at a particular place. The Nycteribiid fauna of India is purely Oriental and most of them have a wide distribution extending from India upto Formosa and Japan.

B. Family **Streblidae** Monticelli, 1898

The family Streblidae was erected by Monticelli (1898) and subsequently Speiser (1900) redefined dividing it into two subfamilies viz. Nycteriboscinae and Streblinae. Jobling (1936) proposed a new classification in, which he included a third subfamily Trichobinae in addition to the two stated above.

(i) *General morphology of the subfamily Nycteriboscinae*

Head Is convex dorsally and is subdivided into three regions such as mediovertex, laterovertex and postvertex by a median longitudinal strip. The head is laterally compressed in the genus *Nycteribosca* and dorso-ventrally compressed in *Raymondia.* In *Raymondia* the arms of the medio vertex are T-shaped and do not enclose any portion of the vertex and hence the postvertex is absent.

Thorax : The much generalised thorax of *Nycteribosca* and *Raymondia* resembles the thorax of Acalyptera. In the genera *Nycteribosca* and *Raymondia* the wings have 5 longitudinal and two cross-veins.

Abdomen Is sacciform, membranous with a few plates and the traces of segmentation are usually absent. The dorsum of the abdomen and its chaetotaxy are correlated with the structure of the wings. In *Nycteribosca* and *Raymondia* there is a distinct groove bordered by setae on the surface of the abdomen. This groove serves as a shelter for the interlocked wings during the movement of the flies in the fur of the bats.

Genitalia : In *Nycteribosca* the aedeagus is a long, membranous tube curved towards the ventral side. It is strengthened ventrally by a chitinous rod and posteriorly it is continuous or articulated with the apodeme. This sheath for the genital organ is formed of phallobase, the parameres and the 9th sternite all fused together. In *Nycteribosca* one paramere is longer than the other. In *Raymondia* the aedeagus is similar to *Nycteribosca* but is shorter. The left paramere is shorter than the right. The asymmetry in *Raymondia* is more marked than in *Nycteribosca.* Female genitalia consists of plates which are apparently homologus with the sclerites called genital plates of Nycteribiids.

(ii) *Key to the genera of the subfamily Nycteriboscinae*

Head broad anteriorly, its dorsal and ventral surfaces convex. Postvertex present	............*Nycteribosca* Speiser, 1900
Head rounded laterally, its dorsal and ventral surfaces flattened. Postvertex absent	.........*Raymondia* Frauenfeld, 1855.

(iii) *Systematic part*

Genus **Nycteribosca** Speiser, 1900

Speiser (1900) erected the genus *Nycteribosca* for specimens formerly placed in the genera *Raymondia*, *Strebla* and *Brachystersina*. Subsequently Jobling (1934-1951) added many species to this genus, bringing the total number to about 25. Of these *N. gigantea* and *N. amboinensis* are reported from India.

1. **Nycteribosca gigantea** Speiser, 1900

(Figs. 95-99)

This species was briefly described and figured by Ferris (1924) and Jobling (1934). Bal and Ahmad (1949) recorded it for the first time from India. This is the largest member of the genus *Nycteribosca*.

Length 3.8-4.2 mm. in both sexes. Colour brown in male and abdomen slightly whitish in female.

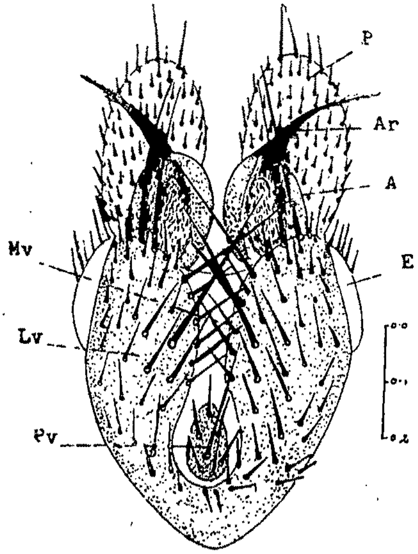


FIG. 95. *Nycteribosca gigantea*. Dorsal view of head.

Head : Moderately compressed laterally. Its dorsal and ventral surfaces convex. Mediovertex membranous, in the form of a narrow strip. Postvertex ellipsoidal with 5-7 moderately long setae and a single much longer seta in the middle. Laterovertices sparsely covered with short and long setae. Eyes big occupying the antero-lateral parts of the head. Palps longer than broad, oval, covered with short setae dorsally and long ones ventrally. Postgenae studded with many short setae. Labella as long as, or longer than theca.

Thorax : Round, convex dorsally and flat ventrally. Mesonotal suture complete. Prescutum with moderately long hairs anteriorly and laterally.

Scutum wide anteriorly bearing a few long hairs as on prescutum and a few more in the posterior region. Scutellum broadly rounded having a few small hairs on the posterior border and long ones in the middle as well as on the anterior border. Mesopleurae and pteropleurae covered with many short hairs. Ventrally, sternopleurae flat, not completely separated, from pleurotrocatines and covered with short hairs all over. Legs iii stouter than the 1st and 2nd pair of legs. Femur and tibia covered with short and thick hairs dorsally and slender and small hairs ventrally. Tarsus 5-segmented, the last one bearing two claws.

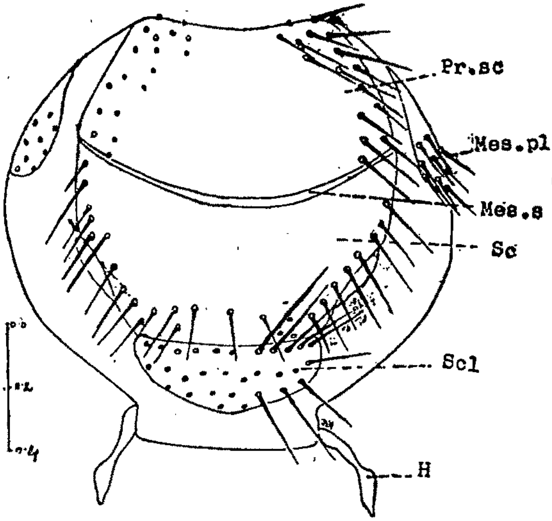


FIG. 96. *Nycteribosca gigantea.* Dorsal view of thorax.

Wings : 3.6-3.8 mm. long. Costal vein thickly setose all along its extension. Subcostal vein absent but the humeral vein present. Cell enclosed by the humeral and costal vein with smaller hairs than those found on the costal vein. R_{4+5} and M_{1+2} parallel near the wing margin. Alula well developed elongated, rounded distally and with delicate hairs on the posterior border. Callipteron with its dorsal surface bare and the ventral surface having a few small hairs. Halteres long, with a knob-like structure distally.

Abdomen in female:The abdomen in both sexes does not show any traces of segmentation. Tergite 1 small with two plates at the sides bearing small hairs. Tergite 2 broad with two plates on either side having strong setae on the surface and on the posterior border. Tergite 3-5 fused, membranous and covered with short spine-like setae bordering the median longitudinal bare area. Tergite 6 membranous and smooth. Tergite 7 with two small sclerites bearing 6-7 long setae of which two in the anterior are long. Proctiger cup-shaped. Cerci small with two short hairs.

Sternite 1+2 weekly chitinized, triangular, the surface with short hairs and a row of little longer hairs at the posterior border. Rest of the ventral surface covered with short spines becoming longer posteriorly. Proctiger covered with a few moderately long hairs, the one at the lateral border and two in the middle longer. Sternite 7 almost triangular bearing moderately long setae on its surface. Sternite 8 rounded and bare. A small poorly chitinized plate dorsally to the genital opening. This is probably the 9th sternite. Sternite 10 poorly chitinized.

Abdomen in male : Aedeagus and apodeme fused, long, narrow, measuring 2.2—2.6 mm. Phallobase long, thicker than aedeagus. Parameres short, thick, the right one being slightly bigger and curved than the left one. Both parameres with very minute hairs near the tip and the surface rough. Sternite 9 with two digitiform appendages and forming the lateral boundry of the genital opening. Digitiform appendages with one long and short setae at the tip. Another pair of digitiform appendages comparatively smaller than the other pair bearing two slender setae at the tip anterior to the genital opening.

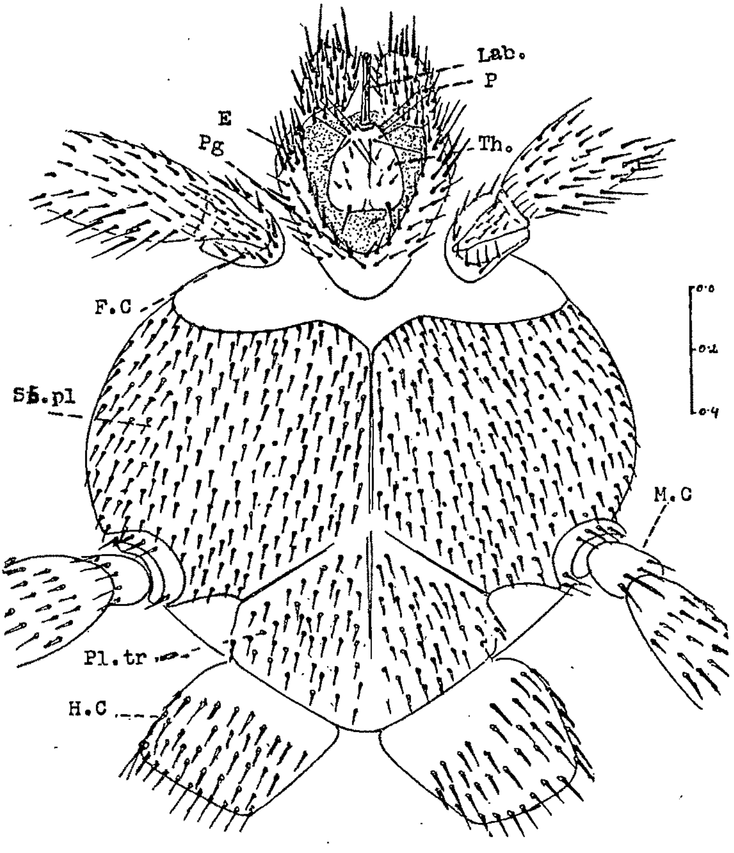


FIG. 97. *Nycteribosca gigantea.* Ventral view of head & thorax.

Host.—Frugivorous bats—*Rousettus leschenaulti* Desm.

Locality : The Jogeshwari, Kanheri and Elephanta Caves, Bombay in 1952 and 1953.

The past record of *N. gigantea* is from Java, Philippines and other Pacific Islands from fruit-eating bats.

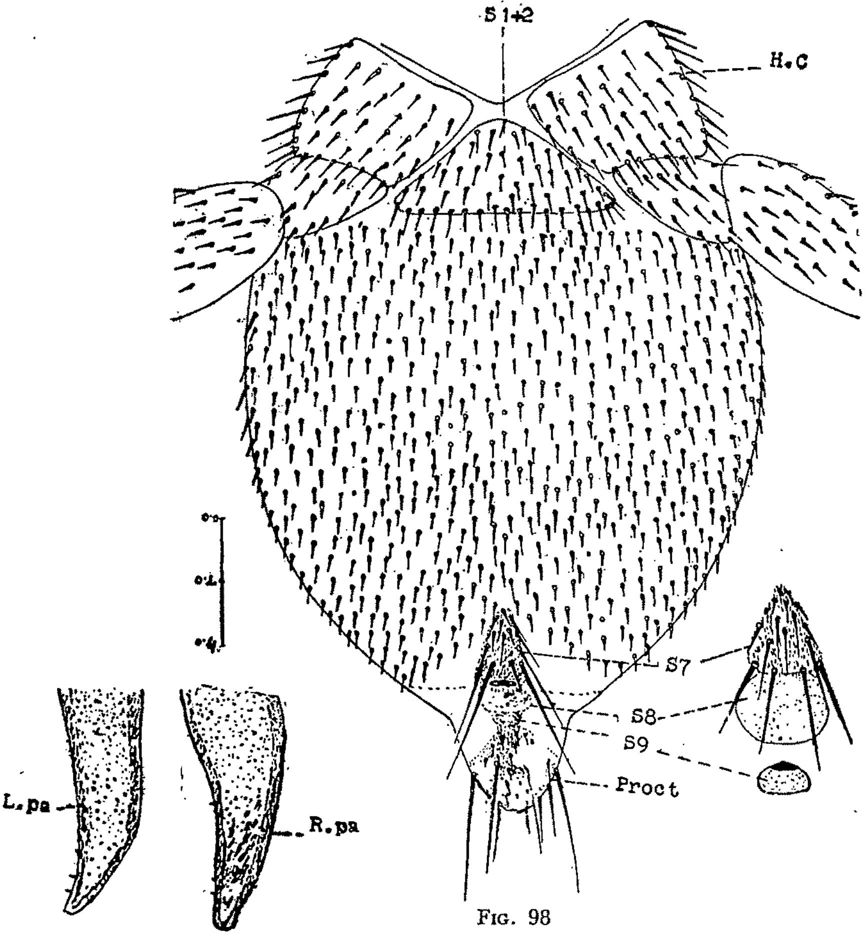


Fig. 98

Fig. 99

Fig. 98. *Nyetreibosca gigentea* Ventral. View of feamle abdomen. Fig. 99. Right and left paramere.

2. **Nycteribosca amboinensis** Speiser, 1900

Jobling (1934) described this species with a number of figures from material collected from Burma and Philippines. In 1951, he stated that *N. amboinensis* is a very variable species almost every specimen differing from the other in its chaetotaxy and the structure of the head.

Modified abdominal segments in female (Fig. 100) : Proctiger with 6 long setae across the middle. Cerci small with two short hairs. Ventrally, proctiger with 2 long setae in the middle rather widely placed and a long seta laterally. Anteriorly 2 moderately long setae rather closely placed across the surface.

Another pair of short setae in the posterior half of the surface. Sternite 7 triangular with 2 curved horns at the ventral surface and the surface with 6-8 short hairs, of which the posterior ones are long. Eighth and ninth sternites absent. Sternite 10 elongated with two posterior horns and highly chitinized in the middle.

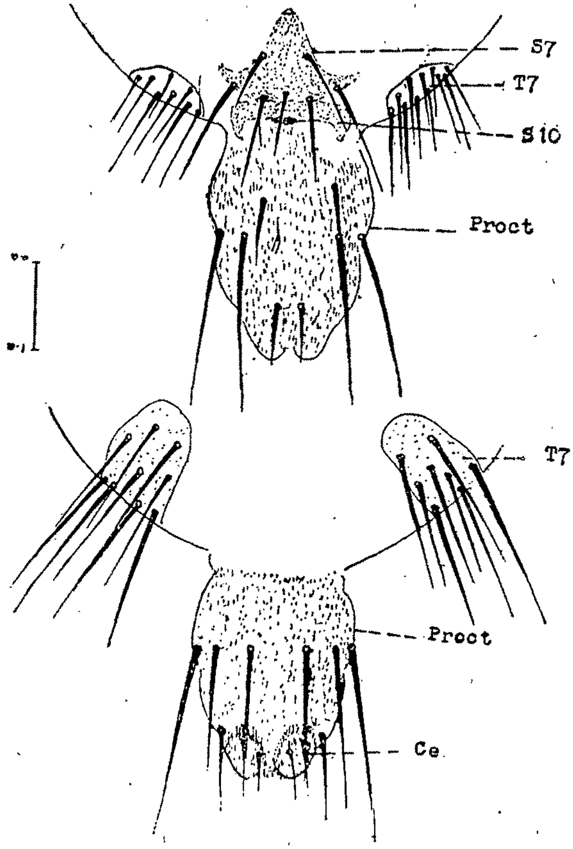


FIG. 100. *Nycteribosca amboinensis*. Ventral & dorsal view of post-abdomen of female.

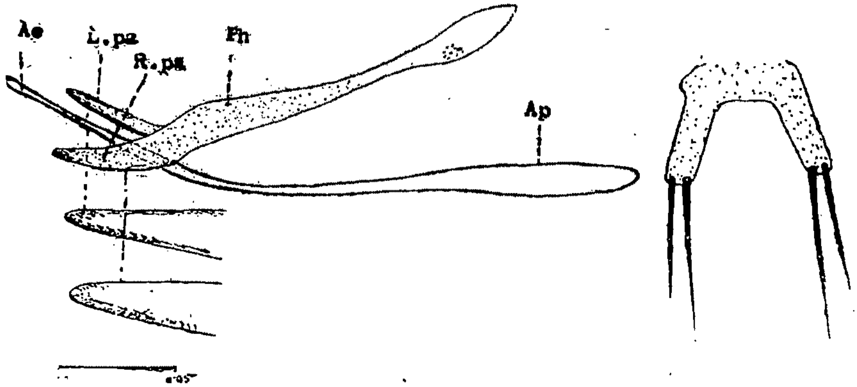


FIG. 101. *Nycteribosca amboinensis*. Male genitalia and digitiform appendage.

Male genitalia (Fig. 101): Aedeagus long, tapering to a thin point and curved towards the ventral side. Aedeagal sheath asymmetrical, the right paramere a little thicker than the left and without any conspicuous minute hairs on it. Sternite 9 highly sclerotized, bearing 2 moderately long setae and forming a ring round the genital opening. Left paramere thin, a little pointed than the right with a few minute hairs. Two sclerites with a slightly square cut ends bearing 2 long setae ventrally to the genital opening.

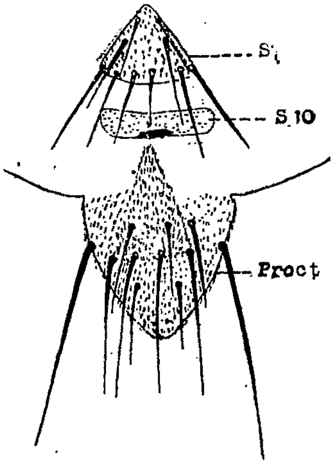


FIG. 102. *Nycteribosca modesta.* Ventral view of post-abdomen.

Host : *Miniopterus fuliginosus* at Mahabaleshwar, Bombay State in 1953.

It is previously recorded from *Miniopterus abversus* in Amboina, on *M. blepotis* at Burma and Australia and other Pacific Islands.

3. **Nycteribosca modesta** Jobling, 1934

This species was first described by Jobling (1934) from Ceylon and later from Burma in 1951. It is parasitic on *Rhinolophus* bats and is recorded from India for the first time.

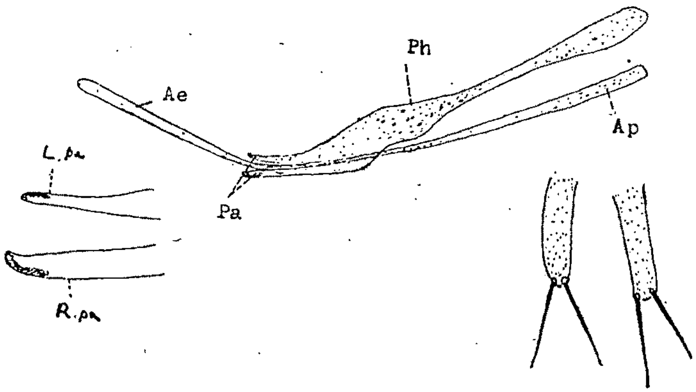


FIG. 103. *Nycteribosca modesta.* Male genitalia and digitiform appendages.

About a hundred specimens of *N. modesta* were collected from *Rhinolophus rouxi* at Tulsi Lake Tunnel, Bombay, in 1953 and the following variations in the structure of the head, wings and chaetotaxy were observed. The postvertex in most of the cases is cochleariform with 3-7 short setae as long ast hose found on laterovertices. In a few cases the mediovertex is wide and not narrow as is found in the typical form described by Jobling. The theca is generally oval, ellipsoidal or conical. The wings also show some variations in the arrangements of the hairs. In the local form the $2M_2$ has more hairs filling the whole area and a few short ones in $1M_2$ near M_{3+4}.. In Ceylon specimens the lateral half of $2M_2$ bears hairs and the rest smooth.

Modified segments of female abdomen (Fig, 102) : Proctiger cup-shaped, longer than broad with a row of 4 long setae across the middle. Cerci small with a few short hairs. Ventrally, proctiger with 4 long setae across the middle, 3 long ones in the anterior half and 2 moderately long ones in the posterior half. Two setae at the sides long and stout. Genital plates two in number, the dorsal plate probably the 10th sternite in the form of a transverse elongated plate without hairs and with a highly sclerotized area in the middle of its posterior border. Ventral genital plate the 7th sternite, triangular with 8-10 long setae on its surface.

Male genitalia (Fig. 103) : Aedeagus and apodeme long, slender, slightly curved and membranous at the tip. Parameres unequal, the right one bigger than the left and not markedly curved at the apex. Two digitiform appendages comparatively longer and stouter with 2 moderately long setae.

Host.—A horse-shoe bat *Rhinolophus rouxi*, Tulsi Lake Tunnel, Bombay 1953.

4. **Nyctribosca taji,** sp. n.

(Figs. 104-110)

At the time of a visit to Agra in 1952 a few bats of *Rhinophoma hardwicki* were collected and 3 female specimens of this species were recovered from them. This species somewhat resembles *Nycteribosca falcozi* particularly in having the basal part of R_{4+5} longer than the *r-m*, but they differ from it in not possessing an oval or ellipsoidal postvertex and the pleurotrocantines slightly more setose than the sternopleurae. They are also found to differ from *N. pygialis* in not possessing the R_{4+5} and M_{1+2} parallel at the wing margin.

Length 3.0 -3.5 mm. in female. Colour yellowish-brown.

Head: Cup-shaped, flattened laterally with the dorsal and ventral surfaces convex. Postvertex round bearing 6-8 short setae, of these 2 anterior ones long.

Mediovertex narrow anteriorly and broad around the postvertex. Many short and erect setae bordering the mediovertex. Lateral margin of the head and the postgenae covered with short hairs. Anterior border of the cheeks with a row of short setae. Eyes prominant slightly protruding out. Ventrally, head covered with short setae, those along the junction with the membranous area a little longer

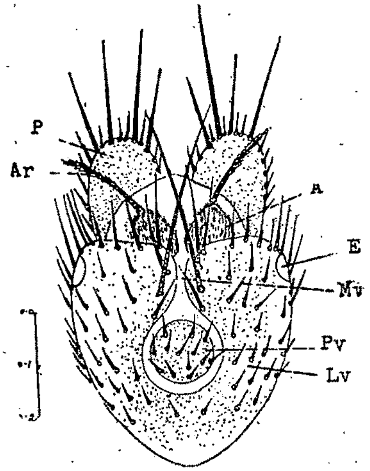


FIG. 104

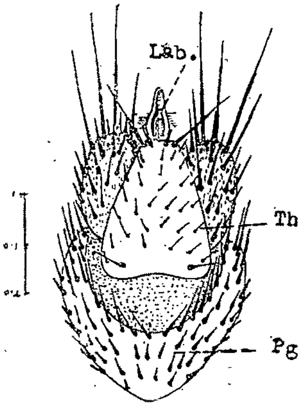


FIG. 105

FIG. 104. *Nycteribosca taji.* Dorsal view of head.
FIG. 105. *Nycteribosca taji.* Ventral dorsal view of head.

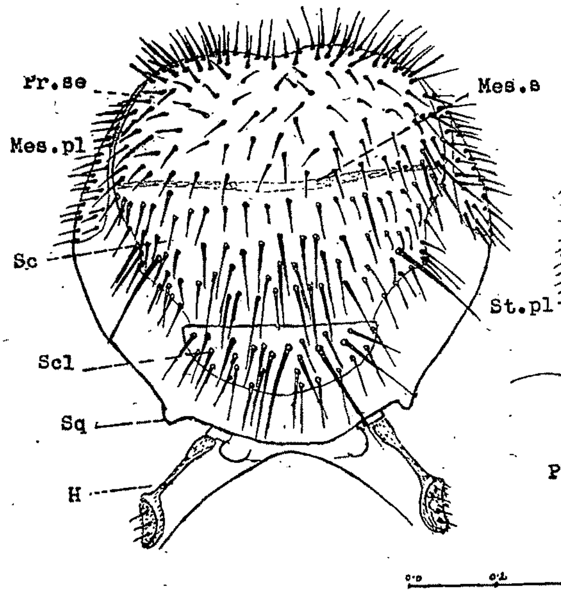


FIG. 106

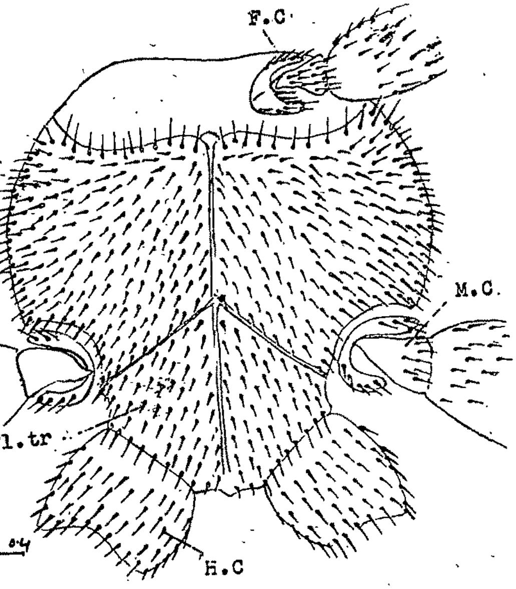


FIG. 107

FIG. 106. Nycteribosca taji Dorsal view of thorax. FIG. 107. Ventral view of thorax.

than the rest. Theca $1\frac{1}{4}$ times longer than broad, triangular with the sides slightly swollen and the surface bearing a few slender hairs. Labella short, less than 1/2 of the length of theca.

Thorax : Broader than long, convex and rounded dorsally. Prescutum longer than the scutum and uniformly covered with long setae. Scutum broad anteriorly bearing long and short setae medially and long ones laterally and posteriorly. Mesonotal suture complete. Scutellum rounded along the posterior border having about 30 setae, the longer ones along the anterior border and shorter ones along the posterior border. Thoracic squamae conical. Mesopleuron and pteropleuron uniformly setose. Ventrally, thorax bristled with short setae. Halteres with a rounded knob and a long pedicel. *Legs* long and heavily covered with medium-sized hairs dorsally and short ones ventrally. Fifth tarsal segment as broad as the total length of the remaining tarsal segments.

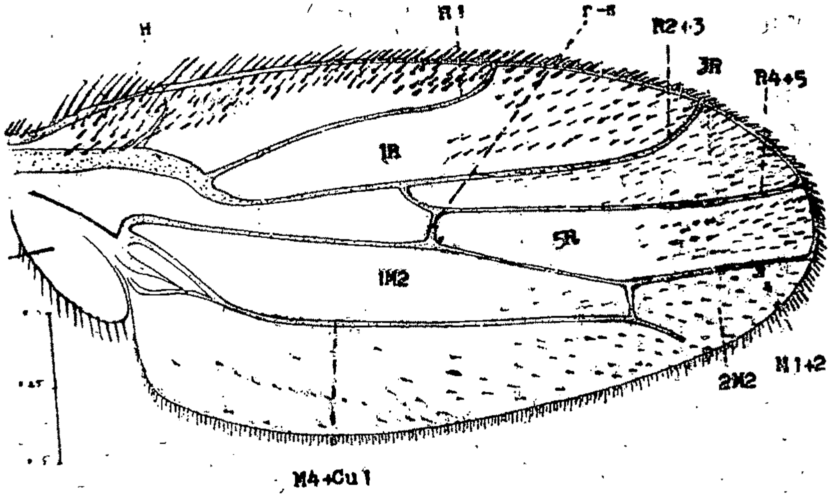
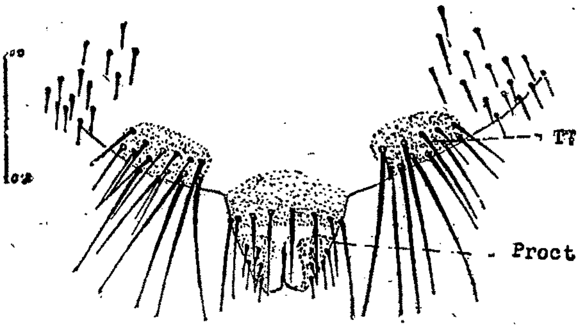


FIG. 108. *Nyctribosca taji* Wing.

Wings : 2.6-2.8 mm. long. R_1 strongly bent at the margin. R_{4+5} and M_{1+2} divergent at the margin. Basal part of the R_{4+5} longer than the *r-m*. Alula with a row of slender hairs along the posterior border and the apex rounded.



IG. 109. *Nyctribosca taji.* Dorsal view of post-abdomen of female.

Abdomen in female : Tergite 1 small with a chitinous plate at the sides bearing a few short setae. Tergite 2 broad with a big chitinous plate at the sides each plate having strong setae posteriorly and shorter ones on the surface. Rest of the abdominal surface membranous and studded with spine-like setae at the sides and moderately long ones bordering the median bare space. Sclerites of the 7th segment roughly broader than long and covered with strong setae. Proctiger cone-shaped with 4 long setae across the surface. Cerci small with a few short hairs on them.

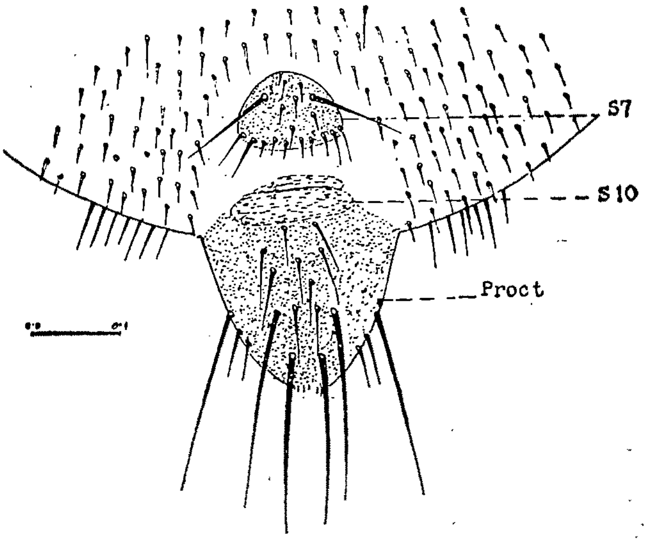


FIG. 110. *Nyctribosca taji.* Ventral view of post-abdomen.

Sternite 1+2 triangular bearing short hairs. A few short and long setae on the proctiger ventrally. Sternite 7 broader than long with the anterior border more convex than the posterior and the surface having short hairs at the posterior border and a few short ones in the middle. Of these two in the anterior half long and strong. Eighth and ninth sternites probably absent. Sternite 10 transversely elongated and smooth.

Host.—A *Rhinophoma hardwicki.* *Locality*: Agra Fort, Uttar Pradesh, in 1953.

Genus **Raymondia** Frauenfeld, 1855

Type species :- *Raymondia huberi* Frauenfeld, 1855

The genus *Raymondia* is represented so far from Palaearctic, Ethiopian, Oriental and Australian Regions. There are more than 14 species under this genus known all over the world. *Raymondia lobulata, R. javanica, R. pseudopago-*

derium and *R. pagoderium* are the only species recorded from Oriental and Australian Regions.

5. **Raymondia joblingi,** sp. n.

(Figs. 111-115)

The present collection of Streblids includes about a hundred specimens of *Raymondia* obtained from *Rhinolophus rouxi* at Tulsi Lake Tunnel, Bombay, in 1953 and 1954. In some characters they are similar to *R. pagoderum* and *R.*

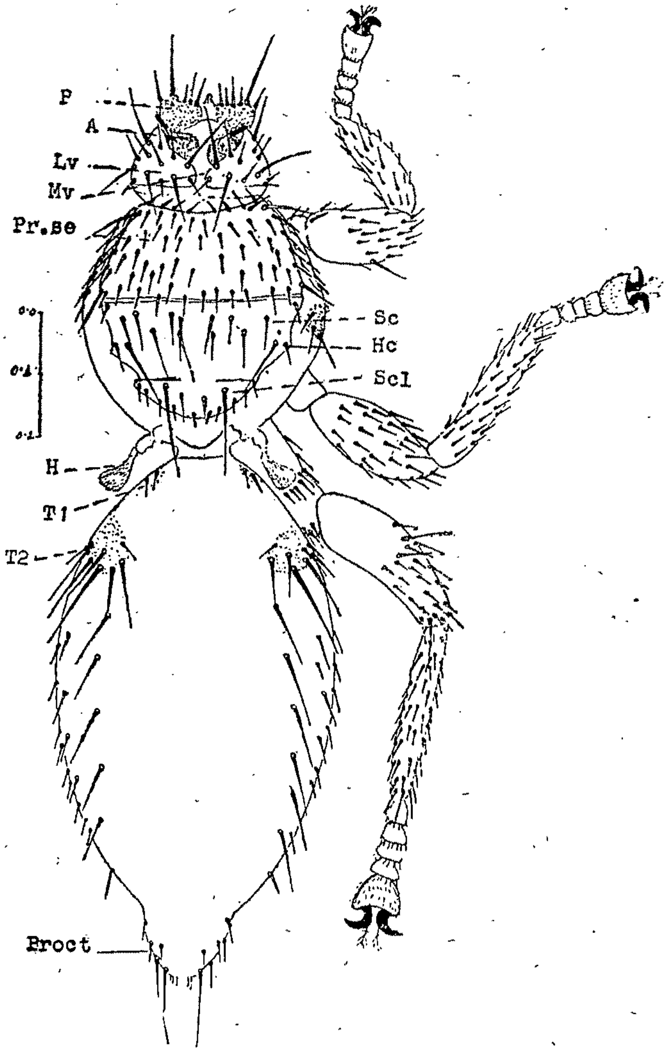


FIG. 111. *Raymondia jobingik* Dorsal view of head, thorax and abdomen of female.

pseudopagoderum. They, however differ from *R. pagoderum* in the absence of setae on the dorsal margin of the occiput and the terminal seta of the alula. They can be differentiated from *R. pseudopagoderum* in the form of the head which is trapezoidal when viewed from above and in having more setae in the marginal cell of the wing. They also differ from it by the different form of the gonapophysis which is broad and has a different curvature.

On account of these important differences the specimens under discussion have been described as new to science and are named after Jobling.

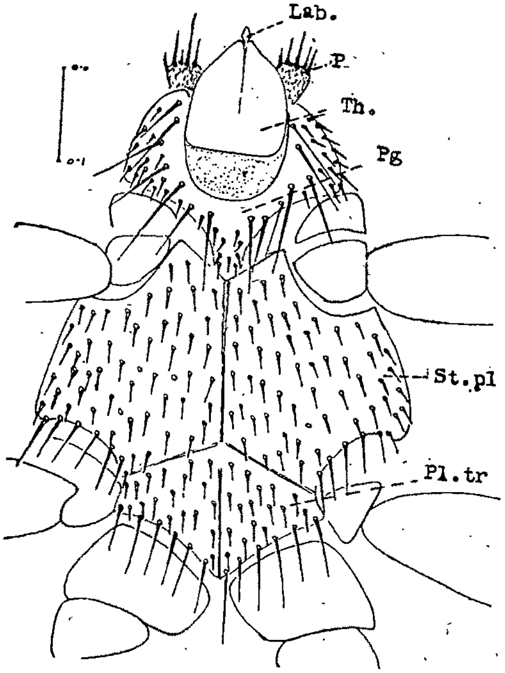


FIG. 112. *Raymondia joblingi.* Ventral view of head and thorax.

Length 1.1-1.3 mm. in both sexes. *Colour* yellowish to light yellowish-brown.

Head : Trapezoidal when viewed from above and the sides rounded. Laterovertices with two setae posteriorly and a few long ones anteriorly. Rest of the surface with a few short setae. Mediovertex membranous, bounded on either side by three pairs of moderately long setae. Postvertex and eyes absent. Arista thick, cylindrical with many fine hairs from base to apex. Palps longer than broad, saucer-shaped with the anterior border almost straight having short and thick setae and the surface smooth. Postgenae covered with short and long setae along the junction with the membranous area. Theca longer than broad with the sides convergent in the anterior half and its surface covered with fine hairs. Labella very short.

Thorax : Nearly as long as broad with the anterolateral part more sloping than in *R. pseudopagoderum.* Prescutum covered with uniform setae. Scutum covered with setae of the same length as those found on the prescutum but much smaller at the sides and in the middle. Mesonotal suture mostly complete but faint in the middle. Scutellum triangular with two strong setae far apart in the centre and moderately long ones rather close to each other posteriorly. Posterrior border of the scutellum bears a few short setae. Ventral surface of thorax flat and uniformly setose except the lateral and posterior margins bearing strong setae. Anterior part of each sternopleuron conical and project under coxa i. Third pair of legs much longer than the 1st and 2nd. Femur and tibia covered with many short hairs ventrally as well as dorsally. A few long hairs on the dorsal surface of the femur.

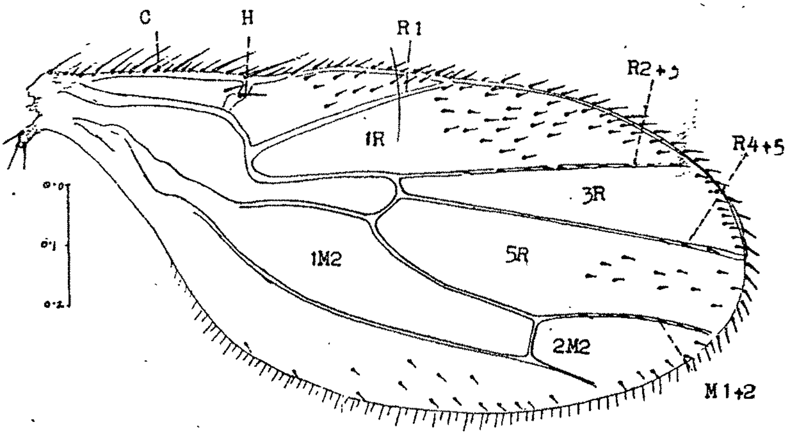


FIG. 113. *Raymondia joblingi.* Wing.

Wings : 1.25 x 0.55 mm. Humeral cell with one seta. Costal cell with a patch of about 13 small hairs while the surface near the humeral vein smooth. 1R with an area of setae occupying more than half the surface and 5R bearing a few small hairs in the apical half of the area. Alula vestigial without any apical seta.

Abdomen in female : Abdomen sparsely covered with setae. Tergite 1 small having 2-3 spine-like setae on the sclerites. Tergite 2 bigger than the 1st with 2 chitinous plates covered with strong setae. A row of 6-8 long setae extending from the 2nd tergite to the postabdomen. Lateral to these the surface bears a few scattered short setae continuous with the setae on the ventral surface.

Sternite 1+2 poorly chitinized with the surface covered with short hairs. Rest of the ventral surface studded with short, spine-like setae. Genital plate poorly chitinized and inconspicuous. Proctiger cup-shaped with 4 dorsal and two lateral setae.

Abdomen in male : Hypopygium broader than long, bowel-shaped with two moderately long setae far apart in the middle and a few short ones at the sides. Ventrally, genital apparatus situated in a gutter-like groove. Right paramere much bigger than the left and markedly different from that of *R. pseudopagoderum.* In *R. joblingi* the right paramere (Fig. 115A) is slightly thicker at the bent end and thin towards the apex while in *R. pseudopagoderum*, the right paramere (Fig. 115B) is also bent but of uniform thickness throughout and tapering abruptly. Surface of the parameres covered with small hairs along the margin. Sensory sclerite short, thick bearing 4 slender hairs and in *R. pseudopagoderum* it is long, thin with 4 long hairs.

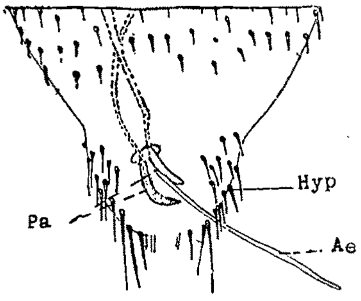


FIG. 114

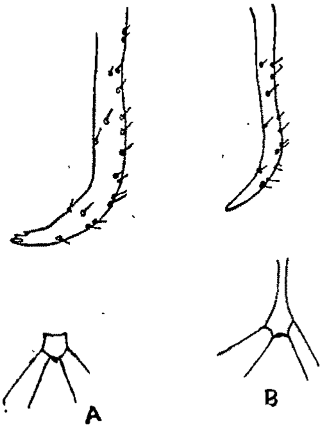


FIG. 115

FIG. 114. *Raymondia joblingi.* Ventral view of abdomen of Male.
FIG. 115 A. *Raymondia joblingi.* Right paramere and sensory sclerite.
B. Right para mere and sensory sclerite of *Raymondia pseudopagoderum.*

Host.—A horse-shoe bat, *Rhinolophus rouxi. Locality* : A Tulsi Lake Tunnel, Bombay, 1953 and 1954.

HEMIPTERA

Family Cimicidae

Genus **Cacodmus** Stal., 1873

This genus contains five species, parasitic on bats and one of them namely *Cacodmus indicus* is known from India (Khandala, Bombay, 1912)).

1. **Cacodmus indicus** Jorden & Rothschild, 1912

(Figs. 116-117)

Half a dozen specimens of this species were obtained from house-bats at Hubli, in 1952. This species is characterised by the hind femur shorter than tibia, head narrower than in *C. ignotis*, the 1st tarsal segment with 2 bristles near the apex and the penis not reaching the centre of the 7th abdominal segment. The earlier description of *C. indicus* by Jordan and Rothschild gives an account of the male with a single figure of the dorsal surface of the head and thorax. So a short description of the modified segments of the female with a figure is added here with a view to filling the gaps.

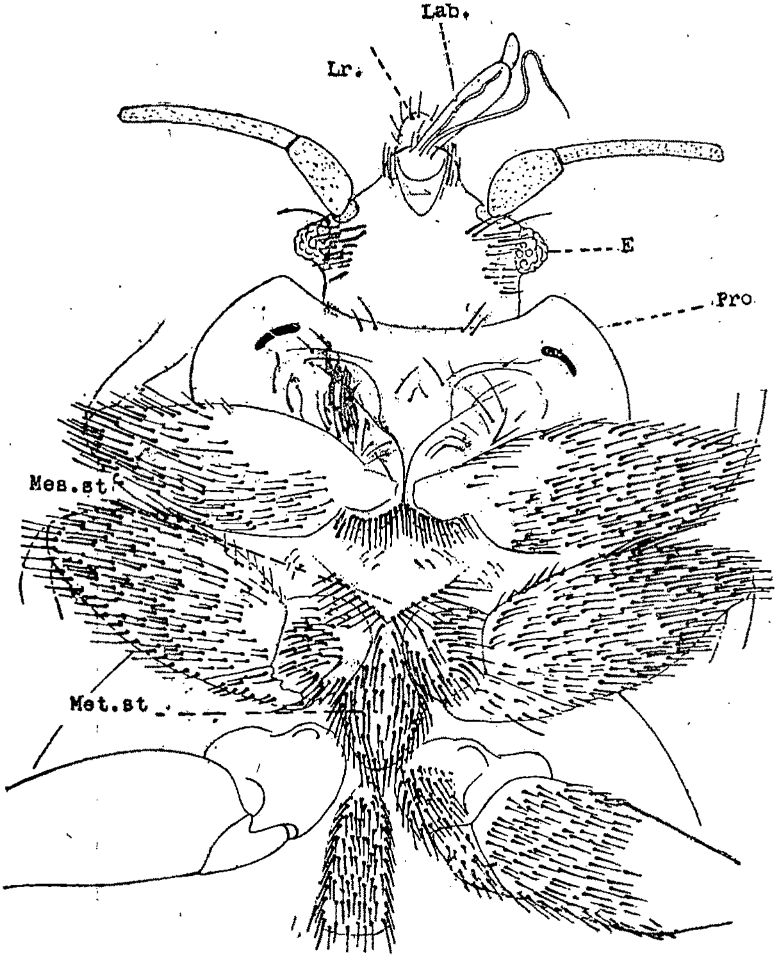


FIG. 116. *Cacodmus indicus.* Ventral view of head and thorax.

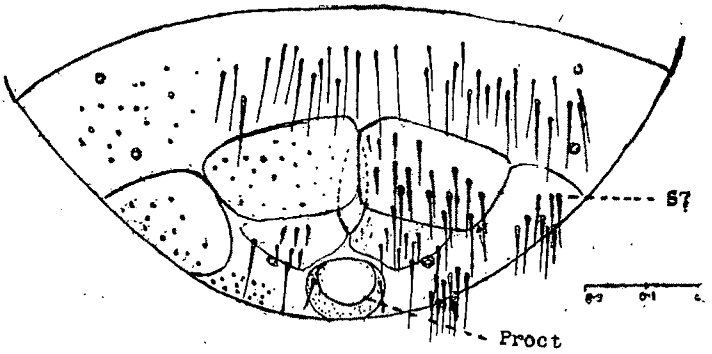


FIG. 117. *Cacodmus indicus.* Modified segment of female abdomen.

Modified segments of female (Fig.117): The 7th and 8th abdominal segments consist of 6 sclerites. The two lateral sclerites of the 7th sternite poorly chitinized bearing a few long bristles in the middle. The two admedian sclerites big bearing long bristles laterally and shorter ones towards the median line forming a gap between them. The two median sclerites indistinct. The other two median sclerites placed anterior to the anal pore, well chitinized bearing two long bristles on the lateral borders and a few slender ones in the posterior half of the region.

Host.—2 males, 1 female and 3 immature specimens from *Pipistrellus ceylonicus chrysothrix*. *Locality* : From an old building, Hubli, 1952.

Genus **Cimex** Linnaeus

2. **Cimex pipistrelli** Jenyns.

(Fig. 118)

C. pipistrelli was recorded from *Scotophilus kulhi* at Madras by Patton, in 1907. Two female specimens of this bat-bug were collected from house-bats at Dharwar in 1953.

5-6 mm. long and 2-2.5 mm. in width.

Head : Similar to that of *Cimex rotundatus* but differing from it in being a little longer. Labrum broader than long. Dorsally the head with a few short hairs and a patch of small hairs at the sides ventrally. Antennae as in *C. rotundatus*. Labellum extending upto the conical projection between the fore-coxae.

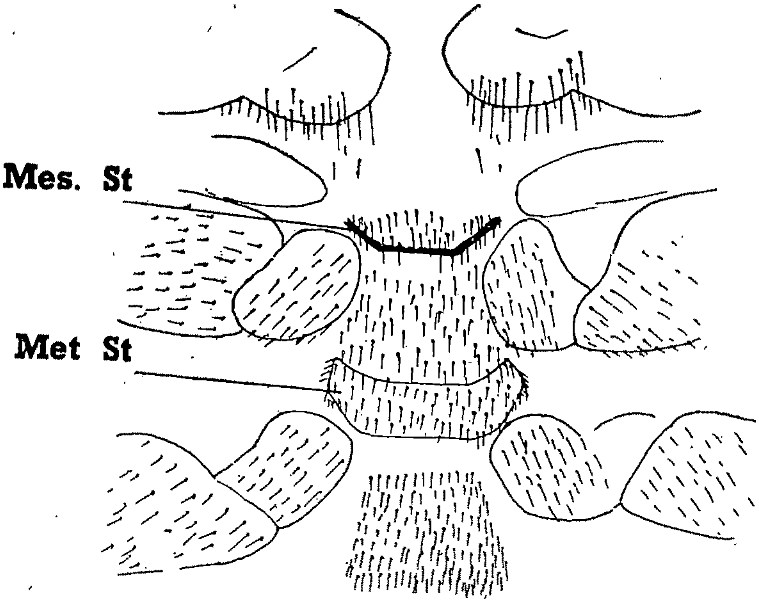


FIG. 118A. *Cimex pipistrelli*. Ventral view of thorax.

Thorax : Prothorax moderately excavated in front and the sides slightly reflexed. Dorsal surface studded with long bristles bent at the apex and not denticulate on the convex side. Bristles on the lateral portion as long as the 1st antennal segment. Antero-lateral angles of prothorax placed away from the posterior border of the eyes. Elytra wider than long, the lateral border sharply curved posteriorly and the surface with long bristles. Mesonotum with median rows of very fine bristles. Metanotum smooth. Ventrally, mesosternum broadly rounded posteriorly being covered with fine bristles. Metasternum as long as broad with a posterior border rounded. Apical tuft of hairs on tibia present. Pseudo-joints absent.

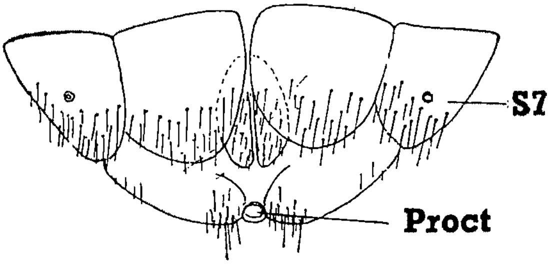


FIG. 118B. *Cimex pipistrelli.* Modified segments of female abdomen.

Abdomen in female : Slender and widest in the region of the 3rd and 4th segments. Abdominal segments covered with short hairs dorsally and much shorter hairs ventrally. Two lateral sclerites of the modified segments triangular with the posterior border rounded and with long bristles on its posterior half. Two admedian plates large bearing long bristles widely separated from each other. Two median plates long, slender, the posterior end rounded and the surface with a few short bristles posteriorly. Other two plates strongly chitinized with the borders rounded and the surface with long bristle. Genital aperture in the form of oblique slit-like opening on the right side of the posterior margin of the 4th segment.

Host.—2 females from *Pipistrellus ceylonicus chrysothrix*. *Locality* : From an old building at Dharwar, in 1953.

SIPHONAPTERA

Family Ischnopsyllidae Wahlgren, 1907

This family includes 8 genera, with about 50 species of which 5 are recorded from India.

Genus **Thaumapsylla** Rothschild, 1907

This genus is represented by four species. Of these *Thaumapsylla breviceps orientalis* has been reported from India.

1. **Thaumapsylla breviceps orientalis** Smit, 1954.

Rothschild briefly described *T. breviceps* from *Rousettus* bats from Cape Colony. Cooreman (1950) recorded it from Belgian Congo, Africa, drawing attention to the variations in the Ethiopian and Oriental species. Subsequently Smit (1954) separated a subspecies *T. breviceps orientalis* from Bombay, India indicating that in the male, the posterior margin of the clasper is nearly concave instead of convex as in *T. breviceps.*

Host.—A frugivorous bat, *Rousettus leschenaulti,* Desm. *Locality* : Kanheri and Elephanta Caves, Bombay, 1953 and 1954.

ACARINA

The bats harbour mites of the families Spinturnicidae, Macronyssidae (Liponyssidae), Myobiidae, Trombiculidae, Laelaptidae, Sarcoptidae, Listrophoridae and Spelaorhynchidae. Of these, the members of the first five families are represented from Bombay State.

A. Family Spinturnicidae Oudemans, 1901

Vitzthum (1941) considers the family Spinturnicidae closely related to Laelaptidae, as some of the members of subfamily Rhinonyssinae of Laelaptidae are similar to Spinturnicidae in general appearance. For this reason the earlier workers placed Rhinonyssinae under Spinturnicidae. The reasons which led Vitzthum (1941) to separate Spinturnicidae from Laelaptidae are the fixed, immovable coxae and the tritosternum. In Laelaptidae the tritosternum is well-developed but reduced in endoparasitic mites of its subfamilies. In Spinturnicidae the tritosternum is absent but a jugular plate is found in its place which is also subject to greater or lesser degree of reduction or totally absent in the genus *Periglischrus.*

Further, Vitzthum separates the two genera, *Spinturnix* and *Ancytropus* on the basis of the jugular plate, the former having a small and round and the latter a large and rectangular plate respectively. The same argument was also put forth by Hirst (1923 and 1927). On the contrary Zumpt (1951) unites these two genera, as the species listed so far under them, show all transitional forms between the two types of jugular plates. He considers the species with a large and rectangular jugular plate as primitive and those with a small and rounded jugular plate or without a jugular plate, as more advanced in phylogeny. But the union of these two genera does not seem to be supported by sufficient reasons, as the jugular plate is not a character of great taxonomic importance. The two genera *Spinturnix* and *Ancytropus* are, therefore, treated here as separate, not only on the basis of jugular plate but chiefly on the size of the 1st pair of legs with or without caruncles and other characters given in the key below.

According to Vitzthum (1941) the family Spinturnicidae was represented by the following six genera:-

(1) *Spinturnix* v. Heyden, 1826
(2) *Ancytropus* Kolenati, 1856
(3) *Periglischrus* Kolenati, 1856
(4) *Meristaspis* Kolenati, 1857
(5) *Tympanospinctus* Berlese, 1918
(6) *Rhinoecius* Cooreman, 1946

Out of these six genera, the *Rhinoecius* with a single species from the nasal cavity of an owl, belongs to the family Rhinonyssidae, as it is now placed in that family. The other genus *Tympanospinctus* is known only from Berlese's inadequate description and according to Vitzthum it probably does not belong to the family Spinturnicidae. Hence these two genera are omitted from the following key.

A Key to the genera of the family Spinturnicidae

1. Peritremes confined to dorsum. Opisthosoma strongly expanded in female. Jugular plate wanting..........*Periglischrus* Kolenati, 1856.
Peritremes confined to dorsum as well as venter. Opisthosoma not expanded in female. Jugular plate always present..........2

2. Leg i with little or no thickening like other legs. Caruncle on tarsus i present..........*Spinturnix* v. Hyden, 1826.
Leg i twice as thick as other legs. Caruncle on tarsus i absent or present..........3

3. Leg i without a caruncle..........*Ancytropus* Kolenati, 1856.
Leg i with a caruncle..........*Meristaspis* Kolenati, 1857.

Genus **Meristaspis** Kolenati, 1857

So far, four species are reported under this genus and three of them namely and *M. lateralis*, *M. lateralis ceylonicus* and *M. taprobanius* are known from Oriental Region.

(1) **Meristaspis (Ancytropus) lateralis** Kolenati, 1857.

(Figs. 119-122)

Hirst (1923) described *Meristaspis lateralis* from frugivorous bats in Palestine. Subsequently, it has been reported from a few places in the Oriental Region. Turk (1950) stated that the Ceylonese material differs from the type species and he, therefore, separated the subspecies *ceylonicus*, on differences in the length of the dorsal setae and the shape of the jugular plate in particular.

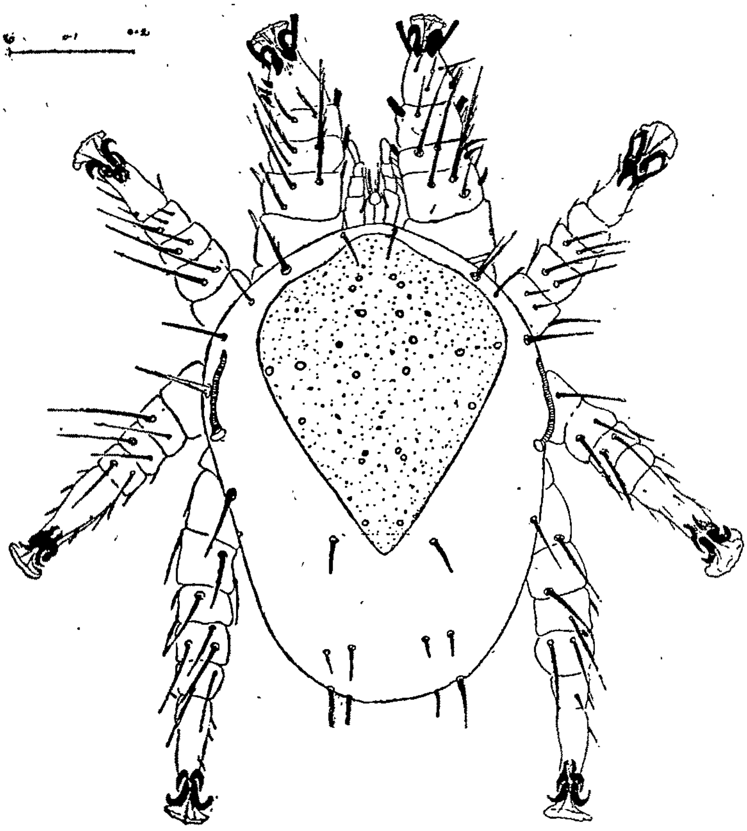


FIG. 119. *Meristaspis lateralis.* Dorsal view of female.

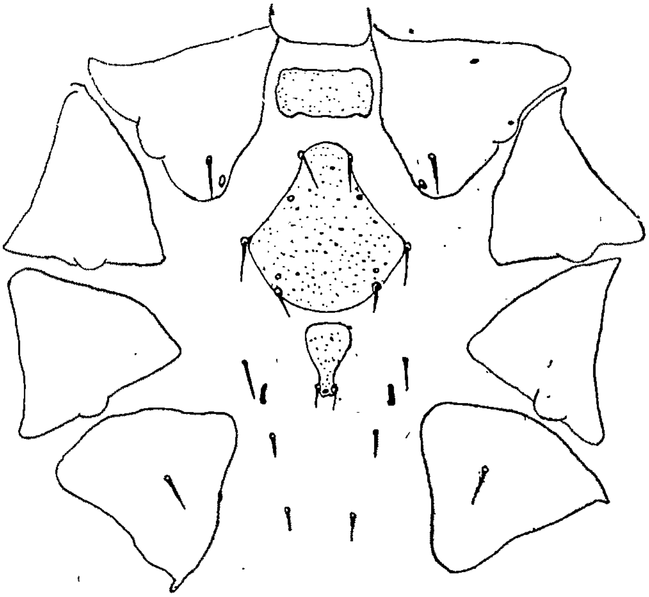


FIG. 120. *Meristaspis lateralis.* Ventral view of female.

Many specimens of this species were collected from Bombay on *Rousettus leschenaulti* and it is recorded for the first time from India. Since a few variations have been noticed in the original descriptions the present material has been thoroughly studied and redescribed below with four figures.

This species is characterised by a well developed transverse line behind the 4th pair of legs.

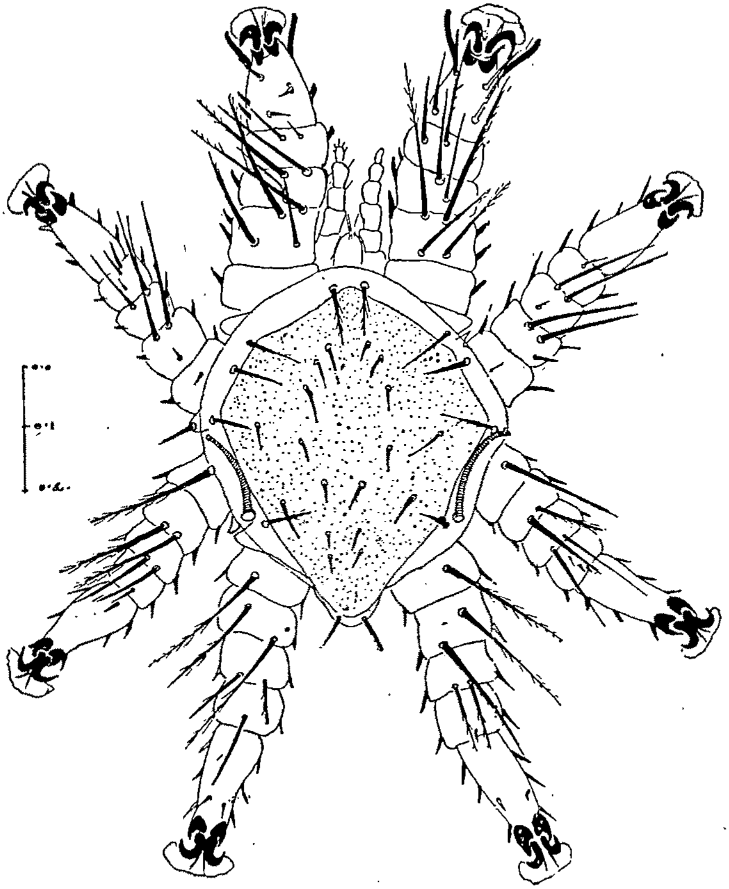


FIG. 121. *Meristaspis lateralis*. Dorsal view of male.

Idiosoma : Body oval, the greatest breadth being in between the 3rd and 4th pair of legs. Body when engorged in female more rounded measuring 0.68 x 0.42 mm. and male 0.58 × 0.38 mm.

Female : *Ventral surface* jugular plate broader than long well chitinized with the corners rounded. *Sternal plate* flask-shaped with 3 pairs of sternal setae at the margins, the surface with 2 pairs of pores and not reticulated. *Genital* *plate* broad anteriorly and constricted towards the posterior end bearing a pair of genital spines. Posteriorly, the ventral surface bears 4 pairs of short setae, the 1st and 2nd pair being situated between the 3rd and 4th pair of legs and the 3rd and 4th pair in the posterior region along the median line. Two minute chitinous rods behind the sternal plate on either side of the genital plate, in level with the metasternal setae, unlike the specimens from Palestine and Cyprus. Peritremes small, in level with the 3rd pair of legs, extending over the ventral surface.

Dorsal surface : *Dorsal shield* longer than broad, with the posterior end pointed and the anterior broadly rounded. Its surface with 8 pairs of median and 3 pairs of lateral pores. A pair of long setae in front of the the dorsal shield,

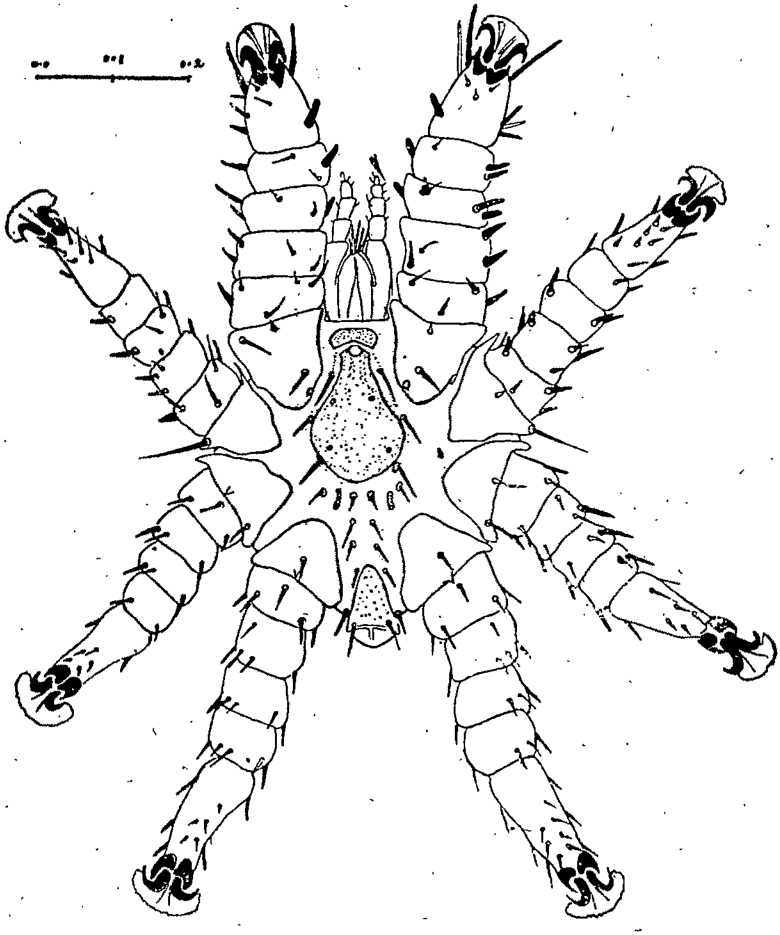


FIG. 122. *Meristaspis lateralis*. Ventral view of male.

3 strong setae laterally, in level with 1st, 2nd and 4th coxa. Opisthosomal region with two short setae placed on either side of the posterior end of the plate, two short ones on either side of the median line, rather apart near the posterior brored and 4th pair of the same length on the hind border.

First pair of legs, thicker than 2nd, 3rd and 4th pair of legs. Dorsally, the legs with strong setae having lateral barbules and with spatula-shaped spines on the inner margin. Tarsus of all legs with a well developed caruncle. Coxae i and iv with a short seta in the middle and coxae ii and iii with a moderately long seta at the inner angle.

Male : *Ventral surface*—Jugular plate as in female but its anterior border convex and posterior concave in accordance with the convexity of the sternal plate anteriorly. *Sternal plate* flask-shaped but more elongated than in female bearing a genital opening at its anterior end. Three pairs of sternal spines and 2 pairs of pores on the surface. Surface not reticulated. Two minute chitinous rods behind the sternal plate, with two short setae in between them. Posteriorly, 4 pairs of short setae, the 1st pair being situated in level with the anterior margin of coxa iv and the remaining three pairs in between the coxa iv. Anal plate longer than broad bearing a pair of short setae bordering the anal opening.

Dorsal surface: Dorsal shield highly chitinized, occupying the whole of the dorsal surface. It bears 8 pairs of median and 3 pairs of lateral pores as in female. Two long setae bordering the anterior and posterior ends. Four long setae with barbules flanking the lateral border of the dorsalplate.

Legs as in female.

Hosts.—A frugivorous bat-*Rousettus leschenaulti* (Desm.) Jogeshwari Elephanta and Kanheri Caves, Bombay. The past record of this species is from Ceylon on *Rousettus ceylonicus*.

Genus **Ancytropus** Kolenati, 1856

Five species are known under the genus *Ancytropus* and two of them *A. aetheopicus* and *A. lavellanus* are reported from Oriental Region.

2. **Ancytropus zelebori** Kolenati, 1856

(Figs. 123-124)

Kolenati's (1856) original description of *A. zelebori* is short and based on one female deposited in the British Museum. Later Hirst (1923) redescribed it from flying-foxes at Palestine. The description of the species by Hirst does not give full details of the dorsal surface. *A. zelebori* is usually found in large numbers on frugivorous bats along with *A. lateralis* and *A. indicus*. This is the first record of this species from India. The male is not yet known.

Idiosoma : Body oval, with abdomen broad posteriorly, measuring 0.85-0.90 × 0.45-0.50 mm. including the palps.

Female : Ventral surface-Jugular plate rectangular with the corners pointed and lying between the 1st pair of coxae. Anterior border concave, with the lateral angles pointed and extending upto the inner border of coxa i. *Sternal plate* highly chitinized, broader than long with the usual 3 pairs of setae and 2 pairs of pores on the surface and placed in between the 2nd and 3rd pair of coxae. In

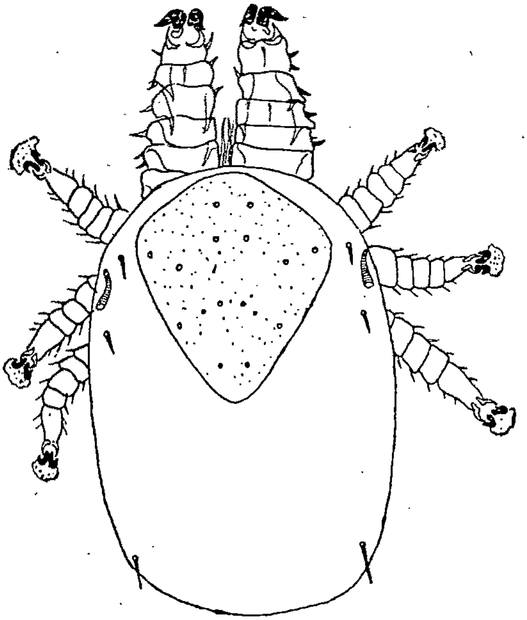


FIG. 123. *Ancytropus zelebori* Dorsal view of female.

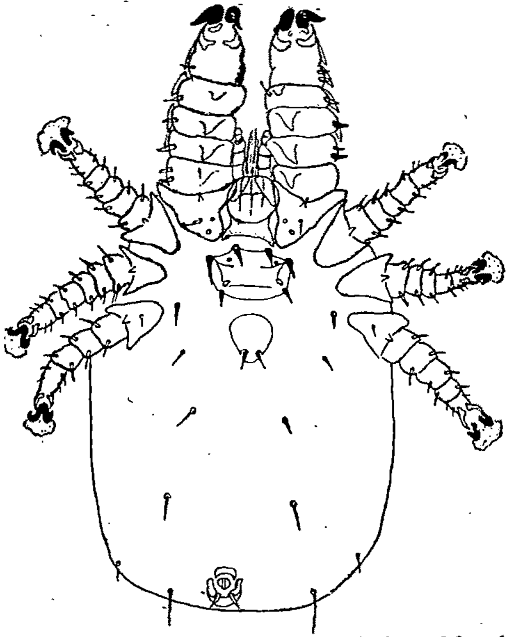


FIG 124. *Ancytropus zelebori.* Ventral view of female.

earlier material the sternal plate is poorly chitinized and much broader. *Genital plate* comparatively poorly chitinized and situated in between the 4th pair of coxae. Shape oval, slightly longer with the posterior border pointed bearing a pair of small setae and the anterior border rounded. Anus situated ventrally with a pair of anal setae posterior to the anal opening. A pair of metasternal setae present. A single seta on either side of the genital opening. Opisthosomal region with eight short and long setae.

Dorsal surface : Dorsal shield longer than broad occupying the anterior half of the body. Five pairs of median and three pairs of longitudinal pores on the surface. Rest of the dorsal surface smooth, except 2 short setae near the legs iii and iv. Two moderately long setae at the hind margin. Peritremes very short, restricted to dorsal surface and slightly extending to the ventral side and placed in level with coxa iii.

Legs : First pair of legs stronger than the 2nd, 3rd and 4th pair of legs. Digits of 1st pair of legs, with sharp setae dorsally and short and thick ones on the lateral border. Claws strongly developed. Tarsus i without a caruncle and tarsi ii, iii and iv with caruncles. Dorsal surface of other legs without any setae and the ventral surface with 2 short spines at the lateral margins of each digits.

Host.—A frugivorous bat-*Rousettus leschenaulti* (Desm.). *Locality :* Jogeshwari, Kanheri and Elephanta Caves, Bombay, December 1952.

The past record of *A. zelebori* is from Palestine on *Rhinolophus microphyllum* and *Pteropus aegupticus.*

3. **Ancytropus indicus,** sp. n.

(Figs. 125-126)

This species resembles *Ancytropus zelebori* in having a strongly developed 1st pair of legs, the tarsus without any caruncle and to some extent in the shape of jugular plate. But it differs from it in the shape of the sternal plate and the presence of peculiarly curved spines on the 1st pair of legs. It is, therefore, described, as new to science, under the name of *Ancytropus indicus.*

Idiosoma : Body oval, broadest at the level of the legs ii and iii and measure 0.75- 0.80 × 0.45 - 0.48 mm. (including palps).

Female: *Ventral surface.* Jugular plate rectangular as in *A. zelebori* with the antero-posterior angle acuminate and postero-lateral corners rounded and placed in between coxa i. Postero-lateral corners lie below the blunt process of the inner border of coxa i. *Sternal plate* flask shaped, broader than long, surface with 3 pairs of customary short setae and 2 pairs of pores. Sternal plate placed in between the coxae ii and iii. *Genital plate* broader than long, with the lateral margins nearly straight and converging anteriorly. Posterior border produced into a rounded projection in the middle bearing a pair of setae of the same length as those found on the sternal plate. Metasternal spines short and placed one on either side of the genital plate, in between coxae iii and iv. Rest of the ventral surface with 2 setae, rather closely placed behind coxa iv and 2 more rather far apart, towards the posterior end. Three to four stout spines along the posterior margin of the abdomen. Anal opening subterminal. Anal plate distinct, with a pair of long setae on it.

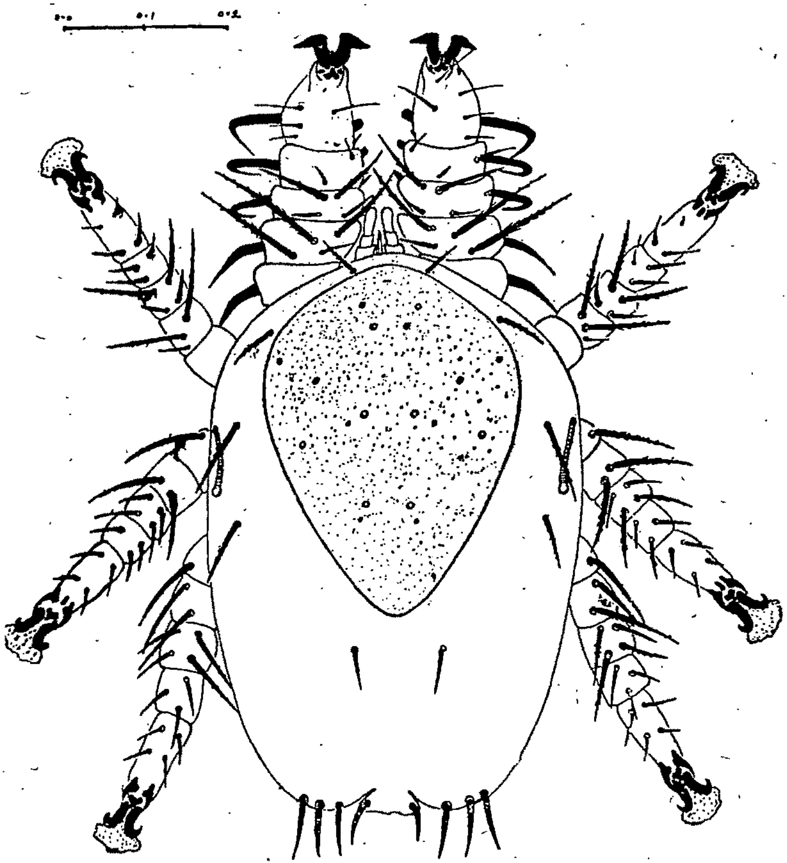


FIG. 125. *Ancytropus indicus*. Dorsal view of female.

Dorsal surface: Dorsol scutum longer than broad, with anterior and posterior ends slightly pointed and widest in the anterior half bearing 6 pairs of median and 3 pairs of lateral pores on the entire surface. Two moderately long setae anterior to the dorsal plate. Three long setae lateral to the dorsal plate, each seta being placed in level with 2nd, 3rd and 4th pair of coxae respectively. A pair of long spines behind the dorsal plate. Rest of the dorsal surface of the abdomen smooth membranous. Peritremes short and placed in level with coxa iii and extend slightly on the ventral surface.

Legs : First pair of legs comparatively stronger than the remaining three pairs, without any caruncle on the tibia and with well developed claws. Inner border of coxa i facing the jugular plate curved at two places, forming two rounded processes, the inner process lying below the lateral portion of the jugular plate. Spur on coxa i small and on others absent. Laterally, the 1st pair of legs with five strong spines bent ventrally so as to cling to the host and the inner border with two spatula-like spines on the tarsus and tibia. The remaining three pair of legs, thin, slender with a distinct caruncle on each tarsis and a few short hairs on the dorsal surface.

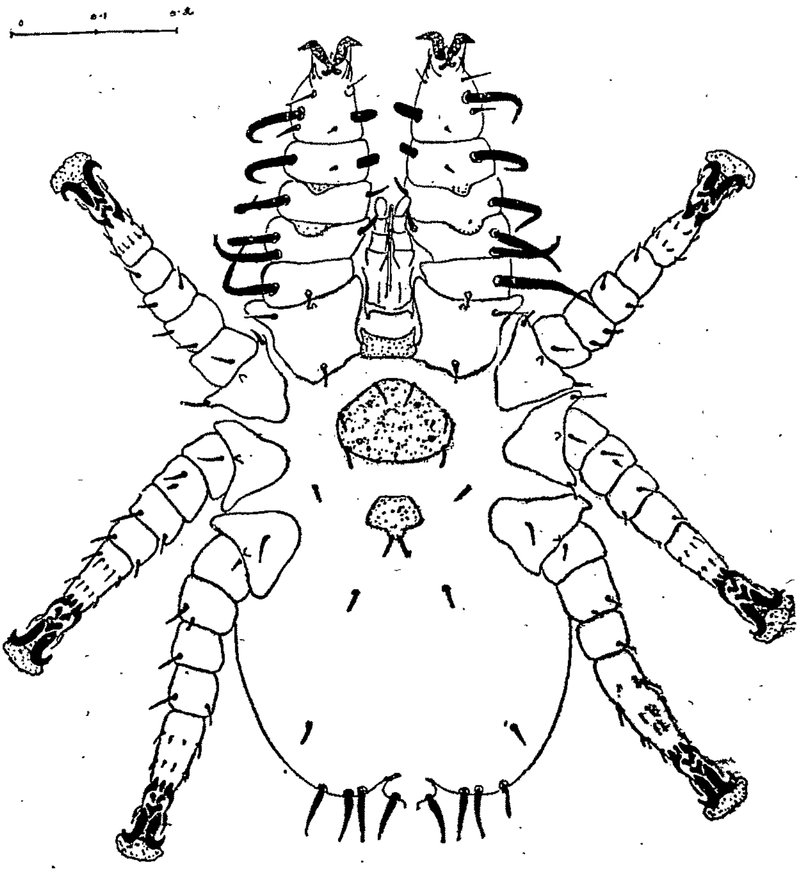


Fig. 126. *Ancytropus indicus.* Ventral view of female.

Host.—A frugivorous bat-*Rousettus lechenaulti* (Desm.) *Locality* : The Jogeshwari and Kanheri Caves, Bombay. February 1952.

4. **Ancytropus kanheri,** sp. n.

(Figs. 127-128).

This species is characterised by a large hook on the tarsus and a small one on the coxa of the first pair of legs, which are highly modified for fastening to the host. Further the mouth parts and the jugular plate seem to wedge in between the 1st pair of legs. The abdomen is stout, membranous and much expanded posteriorly, strengthened by internal chitinous rods and plates. This is the largest of Spinturnicid mite recorded so far. The distinctive character of the leg i is itself sufficient to raise this species to the generic rankbut for the present it is described as a new species under the genus *Ancytropus* until lmore material is examined at a later date.

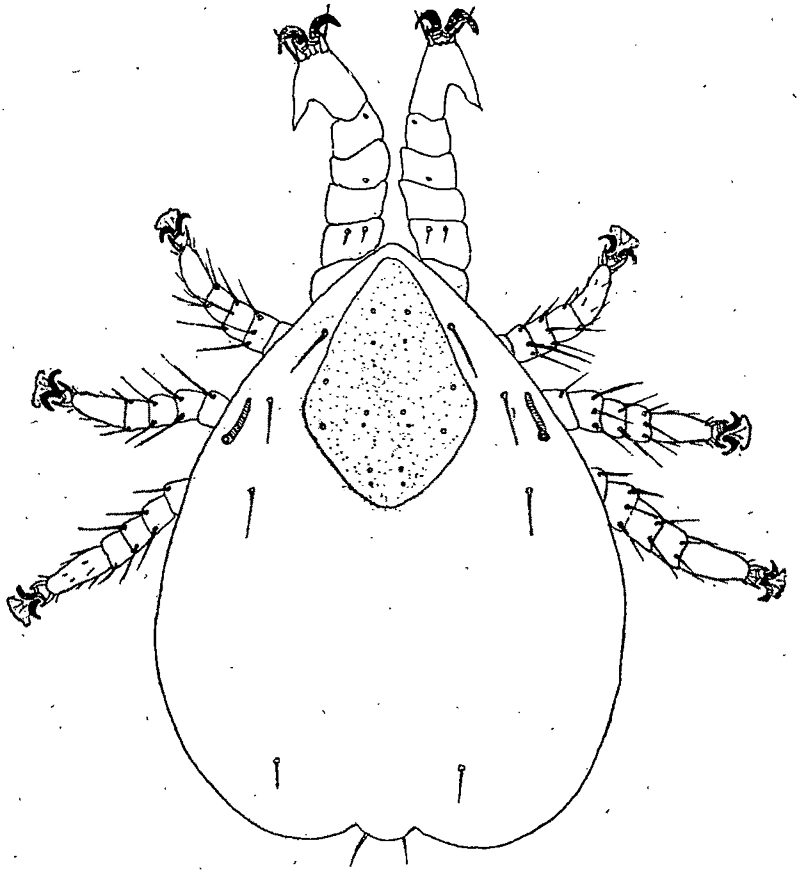


FIG. 127. *Ancytropus kanheri.* Dorsal view of female.

Idiosoma : Body longer than broad with its anterior margin more pointed than the posterior and widest in the region of the opisthosoma. *Length* 1.30 mm. including the palps. *Breadth* 0.96 mm.

Female : Ventral surface Jugular plate longer than broad with the anterior border concave, the posterior convex and the sides converging posteriorly, in close apposition with coxa i. *Sternal plate* flask-shaped; longer than broad, very poorly chitinized bearing 3 pairs of very minute setae and 2 pairs of pores on the surface. As it is poorly chitinized it is rather difficult to detect unless the specimen is stained with acid fuchsin. It lies close to the inner margin and completely in between coxa ii. *Genital plate* inconspicuous and difficult to identify in mounted slides. Metasternal setae as long as the sternal setae and situated in level with the posterior border of coxa iii. Besides, the abdomen bears 2 short setae, rather far apart, in the middle of the opisthosomal region and moderately long ones on either side of the middle line near the anal plate. Hind border with a single long setae lateraly.

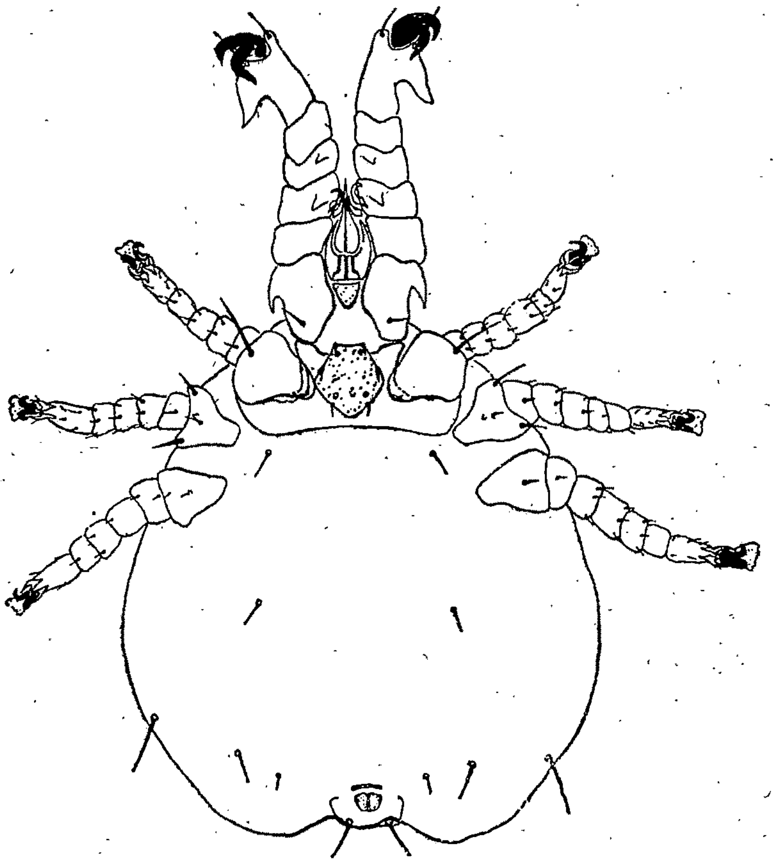


FIG. 128. *Ancytropus kanheri.* Ventral view of female.

Dorsal surface : Dorsal scutum small, longer than broad and widest in the posterior half bearing 6 pairs of median and 2 pairs of lateral pores on the surface. Two long setae flanking on either side anterior to the middle of the dorsal plate. Besides, a long seta in between the peritreme and the dorsal plate and one more seta, on each side of the posterior to the plate. Rest of the dorsal surface of the abdomen smooth except a single pair of setae in the opisthosomal region near the hind margin.

Peritremes small, confined dorsally, as well as ventrally and placed in level with coxa iii.

Legs : First pair of legs strongly developed and situated close to each other. Two recurved hooks, the anterior bigger placed on tarsus and the posterior smaller on the coxa. Surface of leg i without any setae except a few small ones on the dorsal surface. Caruncle on leg i wanting. Claws well developed. Second, third, and fourth pair of legs comparatively much smaller, of equal length, with a well developed caruncle and claws. Chaetotaxy of legs simple having a few short setae on the dorsal surface.

Male not known.

Host.—A frugivorous bat-*Rousettus leschenaulti* (Desm.). *Locality* : Jogeshwari, Kanheri and Elephanta Caves, Bombay, 1953.

Genus **Spinturnix** von Heyden, 1826

About 22 species have been recorded under the genus *Spinturnix* but none of them has been in the past reported from India.

5. **Spinturnix psi** Kolenati, 1856

(Figs. 129-132)

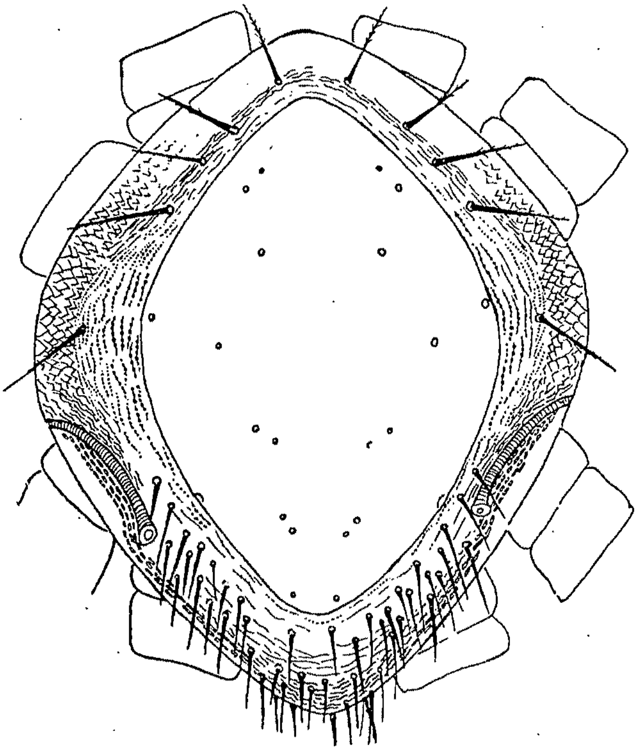


FIG. 129. *Spinturnix psi.* Dorsal view of female abdomen.

Kolenati (1856) recorded this species from *Miniopterus fuliginosus* at Serbia. Later, Hirst (1927) described it from Ajaccio giving a short account of only the ventral surface of the male and female. His description of the male specimen is from *Miniopterus schreibersi* and that of the female from *Rhinolophus ferrum-equinum.*

A large series of specimens of *Spinturnix psi* were collected from *Minipterus fuliginosus* at Mahabaleshwar in 1953 and their close study revealed that the males agree with the description of Hirst but the females differ, particularly with regard to the shape of the jugular and sternal plates.

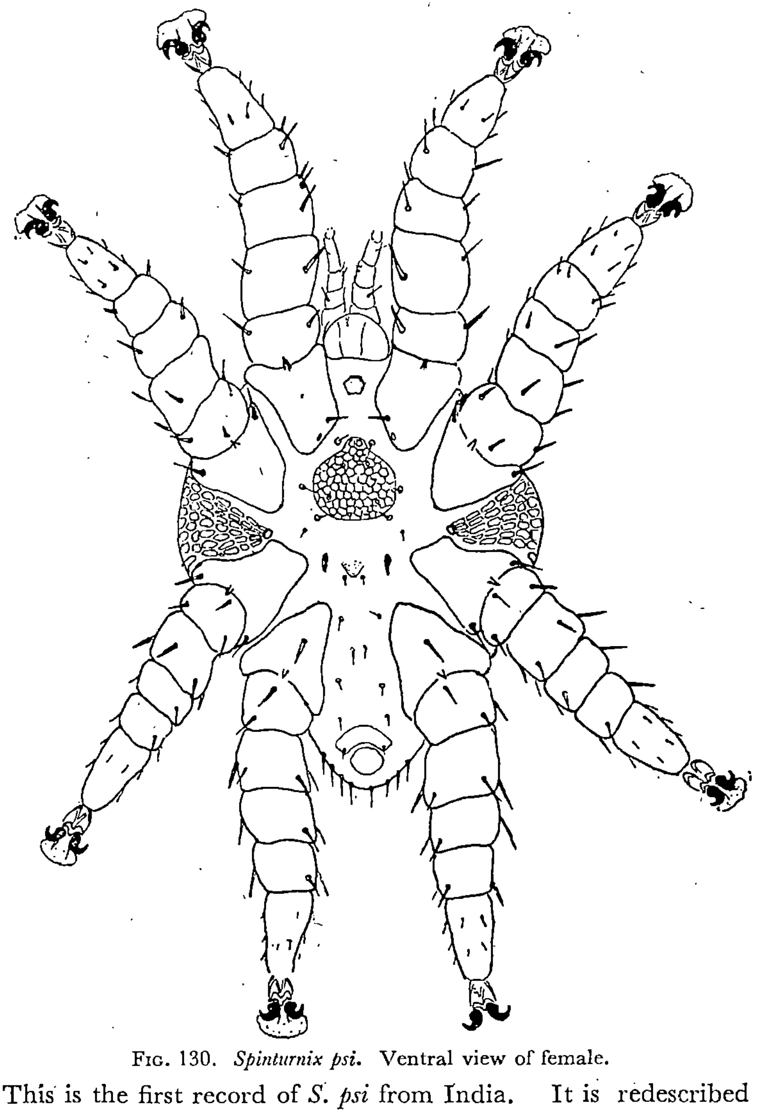


FIG. 130. *Spinturnix psi.* Ventral view of female.

This is the first record of *S. psi* from India. It is redescribed here in detail with a view to filling the gaps in the original description and also pointing out the differences between the Indian specimens and those described previously.

Idiosoma : Body oval, the greatest breadth being in level with the 2nd and 3rd pair of legs. Opisthosoma not bilobed posteriorly. Length from the hind margin upto the extremity of the palps in female 1.2 × 1.05 mm. and in male 0.90 × 1.0 mm.

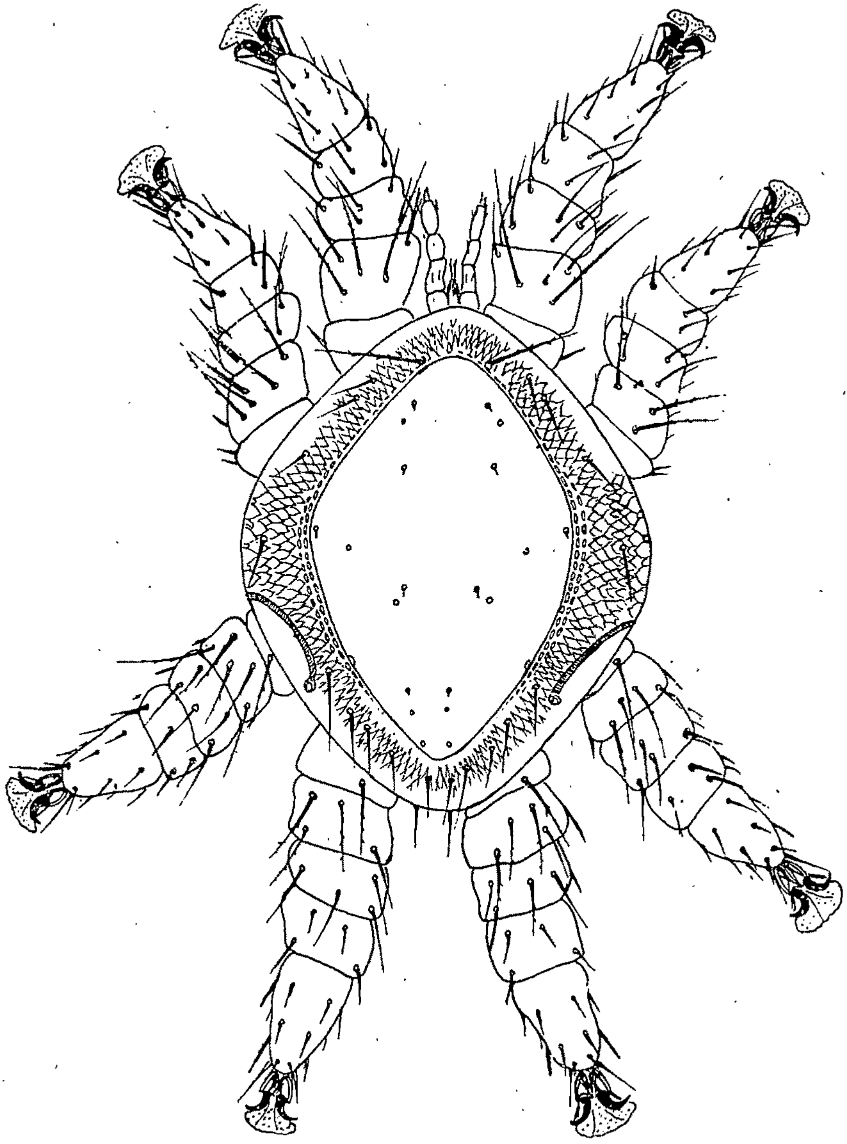


FIG. 131. *Spinturnix psi.* Dorsal view of male.

Female : *Ventral surface. Sternal plate* flask-shaped, nearly as broad as long, with the usual three pairs of short marginal setae and measuring 0.12-0.14 mm., along the greatest diameter. Portion anterior to the neck, rounded and not pointed as in *S. vespertilionis.* Surface with fine reticulations and with 2 pairs of pores. It lies in between the coxa ii and partly between coxa i. *Jugular* *plate* small, hexagonal in shape with the posterior border slightly concave and placed between coxa i. *Genital* plate poorly chitinized and located in between the 3rd pair of coxae and bears a pair of short spines at its pointed end. Metassternal platelets midway between the genital plate and the 3rd pair of coxae. Four pairs of short setae between 4th pair of coxae and anal plate. Anal plate narrow, crescent-shaped, with a pair of short spines on its extremity. Anal aperture roughly circular.

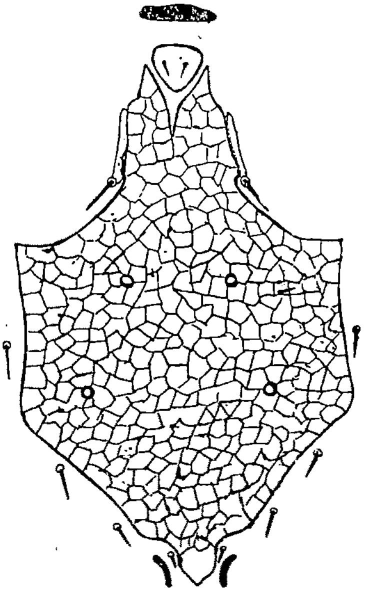


FIG. 132. *Spinturnix psi.* Jugular and sternal plate.

Dorsal surface : Dorsal plate big, ovoidal, the anterior and posterior ends pointed and widest in the middle with 8 pairs of median and 2 pairs of lateral pores on the surface. Soft integument surrounding the shield roughened with small triangular scale-like plates and platelets, arranged in a definite pattern. Soft integument with two strong pilose spines flanking on either side of the anterior pointed end of the dorsal plate. In addition, four long pilose spines flanking on either side of the anterior half of the dorsal plate. About 40 long, pilose spines present on the soft integument occupying the podosomal region behind the peritremes. Peritremes in the form of a slender tube, single and in level with coxa iii.

Legs : Of equal length and of uniform thickness with a few setae at the margins of each segment and covered with moderately long setae dorsally as well as ventrally.

Male : *Ventral surface. Sternal plate* with five pairs of short spines closely flanking its borders and two pairs of pores on its surface. Reticulations on the surface hexagonal in network. Posterior end narrow, pointed, having lateral borders concave between the 3rd and 4th sternal spines. Metasternal platelets present, closely flanking the posterior end of the sternal plate with a 5th pair of sternal spines in between them. Sternal plate in *Spinturnix psi* differs from that of *S. vespertilionis*, *S. pipistrellus* and *S. semilunaris* by the number of sternal spines and shape. In *S. vespirtilionis* the sternal spines are on the plate and the metasternal platelets are absent. *S. pipistrellus* differs from *S. psi* in having only 3 pairs of sternal spines while *S. semilunaris* differs from *S. psi* in possessing the posterior end of the sternal plate bilobed. Four pairs of sufficiently long spines, between coxa iv. Of these the anterior pair placed in the middle, in level with the anterior border of coxa iv. Paired anal spines present on the posterior end of the shield. Anal plate longer than broad and subtriangular in appearance. *Peritremes* in the form of wide strips with an opening near the anterior border of coxa iii.

Dorsal surface : *Dorsal shield* as in female bearing 8 pairs of median and 2 pairs of lateral pores. Soft integument surrounding the dorsal plate studded with small, conical, scale-like, triangular plates which are characteristic in the male. A pair of long, pilose spines, anterior to the scutum and four spines of moderate length, on either side flanking the scutum in the propodosomal region. Posteriorly, soft integument with 10-12 long spines. *Peritremes* and legs as in female.

Host.—Miniopterus fuliginosus (Hard.) *Locality* Mahabaleshwar, Bombay State, 1953.

6. **Spinturnix euryalis orientalis,** n. subsp.

(Figs. 133-135)

Hirst (1927) recorded *Spinturnix euryalis* from *Rhinolophus euryalis* at Corsica and also from *Rhinolophus ferrum equinum*, Cheddar Caves giving a brief account and two figures of the ventral surface of the male and female.

About a dozen specimens were collected from *Rhinolophus rouxi*, Tulsi Lake Tunnel, Bombay, in 1953. In these specimens the jugular plate of the female is nearly twice as broad as long with the anterior border straight, the posterior convex and corners rounded. In male, the jugular plate is big and broader than long. The sternal plate is much elongated and well chitinized in both sexes. In addition the dorsal plate has a distinct spine-like process anteriorly. In view of these differences the specimens under discussion have been assigned to a separate subspecies namely *S. euryalis orientalis*.

Idiosoma : Body oval in engorged female and egg-shaped in male. Female 0.8 -1.8 × 0.45 - 0.60 mm. Male 0.50 - 0.60 × 0.40 - 0.50 mm.

Female : Ventral surface. Jugular plate nearly twice as broad as long with the posterior border straight and anterior convex. *Sternal plate* flask-shaped, well chitinized having three pairs of strong spines along the margin and 2 pairs of pores on the surface. It lies in between the 1st, 2nd and partly between the

3rd pair of coxae. *Genital plate* small, with a pair of moderately long spines on its posterior border. It lies between coxae iii. A small pore on either side of the genital plate which probably represents the opening of trachea. Two strong spines on either side in level with and anterior to the genital plate. About 40 long spines, shorter than the sternal, between the genital plate and the anus. Surface around the sternal plate roughened with elevations and grooves. Hairs on the anal plate short and spine-like.

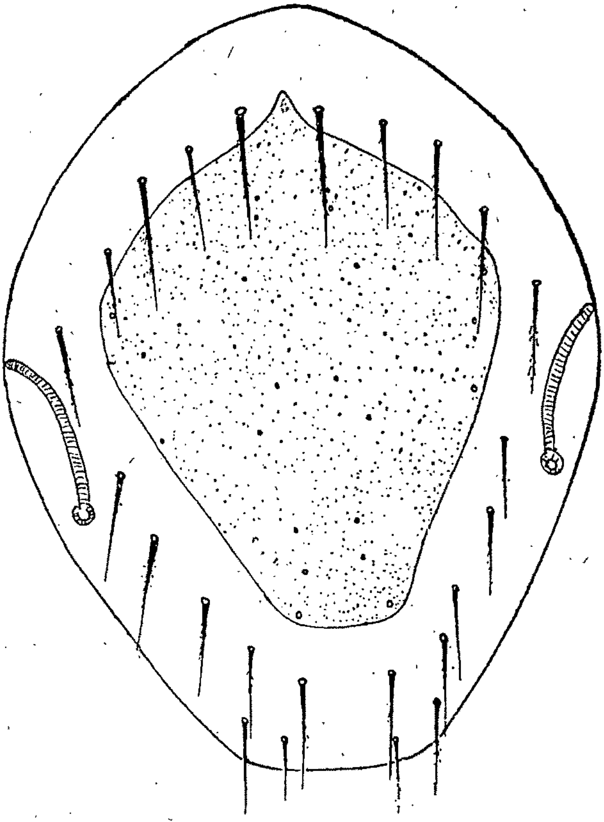


FIG. 133. *Spinturnix euryalis orientalis*. Dorsal view of female.

Dorsal surface : Dorsal plate longer than broad, mostly covering the entire surface with a blunt projection at its anterior border and its posterior end more or less rounded. Eight pairs of median and threep airs of lateral pores without spines on the surface. Soft integument surrounding the scutum with ridges and grooves. A long spine with barbules on either side of the pointed anterior projection. Four long spines with barbules flanking on either side of the plate, anterior to the peritremes and three equally long spines in the region of the 3rd and 4th pair of coxae. Behind the scutum, the soft integument sparsely covered with 10-14 long spines. Peritremes long and placed above coxa iii.

Legs of equal length, with a well developed caruncle on all four tarsi. Hairs on the dorsal surface long and on the ventral surface short. Two long spines with barbules on the dorsal surface of femur of all legs.

Male : *Ventral surface* . *Jugular plate* 3 times broader than long with the anterior and posterior sides straight. *Sternal plate* with the usual 3 pairs long spines along the margin and two pairs of pores on the surface. Posteriorly, behind the 3rd pair of spines, thes ternal plate merges with another weakly chitinized plate bearing a pair of shorter spines. Hence it appears that the sternal plate bears 4 pairs of spines. It lies in between the 1st and 2nd pari of coxae. A pair of stouter spine in level with the 4th pair of sternal spines, as in female. Two pores behind the sternal plate. The region between the sternal plate and the posterior border studded with about 20 spines.

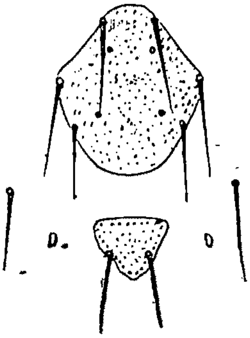


FIG. 134.

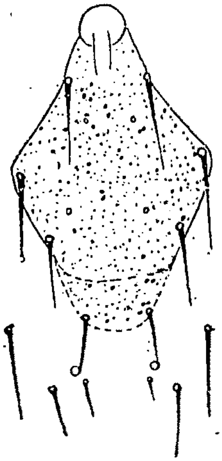


FIG. 135.

FIG. 134. *Spinturnix euryalis orientalis*. Jugular, sternal and genital plate of female.
FIG. 135. *Spinturniz euryalis orientalis*. Jugular and sternal plate of male.

Dorsal surface : *Dorsal plate* with the same number of pores as those found in female. Three long spines with barbules lateral to the soft integument. Behind the dorsal plate, the soft integument bears four spines in line with the posterior border. Peritremes and legs as in female.

Host.—Horse-shoe bats, *Rhinolophus rouxi* (Temn.). *Location* : Tulsi lake Tunnel, Bombay 1953.

Genus **Periglischrus** Kolenati, 1857

This genus is distinguished from other genera of the family Spinturnicidae in having peritremes lying dorsally and the abdomen usually expanded in the opisthosomal region. Out of about nine species reported under this genus, seven are from the Palaearctic Region and one from each of the Ethiopian and American Regions. But the genus *Periglischrus* is not so far reported from the Oriental Region and the present record of *P. rhinolophi* from Bombay is the first one from India.

7. **Periglischrus rhinolophi,** sp. n.

(Figs. 136-139)

This species resembles *Periglischrus africana* Zumpt (1950) the only representative of the Ethiopian Region, in the shape of the body and the sternal plate but it differs from it in possessing the sternal plate with the usual 3 pairs of marginal and 2 pairs of surface pores, instead of numerous as in *P. africana*. It also differs from *P. africana* in possessing numerous platelets on the dorsal surface. The large series of specimens of this mite collected from *Rhinolophus rouxi* at Bombay are placed under a new species called *P. rhinolophi.*

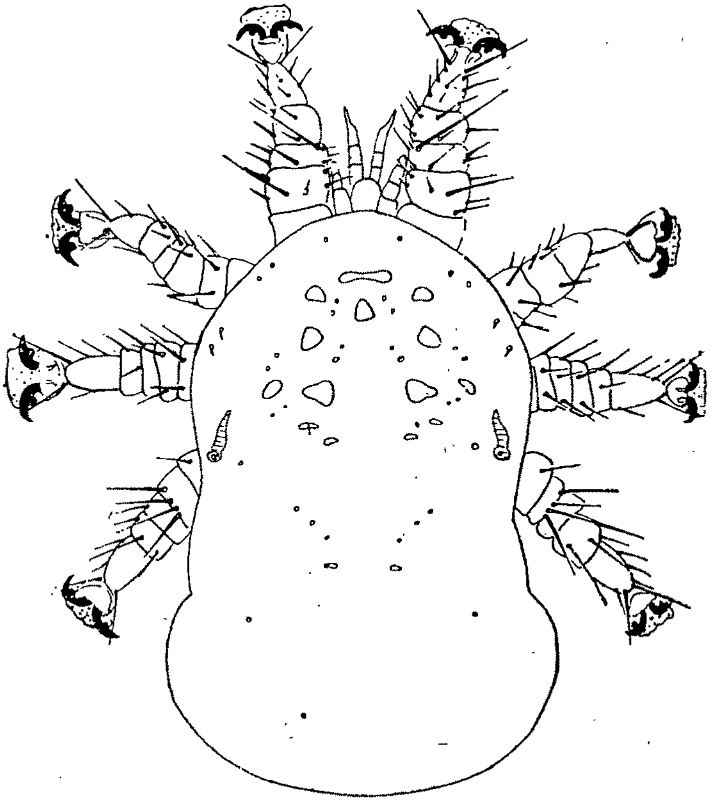


FIG. 136. *Periglischrus rhinolophi.* Dorsal view of female.

Idiosoma : Body longer than broad, with a constriction behind the 4th pair of legs. Propodosomal region rounded and the opisthosomal region expanded. Female 0.78×0.52 mm. Male 0.50×0.32 mm.

Female : Ventral surface, Sternal plate poorly chitinized possessing 3 pairs of marginal pores without setae and 2pairs of pores on the surface. It lies between coxa ii. *Genital plate* indistinguishable but with a pair of fine spines lying medially in level with the anterior border of coxa iv. A pair of small metasternal plates present. Four pairs of pores without seta in the posterior half of the body, the anterior pair situated between coxae iii and the posterior pair between coxae iv. Opisthosomal region with 3 pairs of minute setae. Anal plate situated ventrally at the junction with the expanded portion of the abdomen bearing a pair of small spines.

Dorsal surface : *Dorsal plate* reduced to 12-14 platelets, some of these poorly chitinized, small and indistinguishable. Eight pairs of median and ten pairs of lateral pores on the dorsal surface. Two spines laterally between the 2nd and 3rd pair of legs. Peritremes small, placed dorsally between the 3rd and 4th pair of legs.

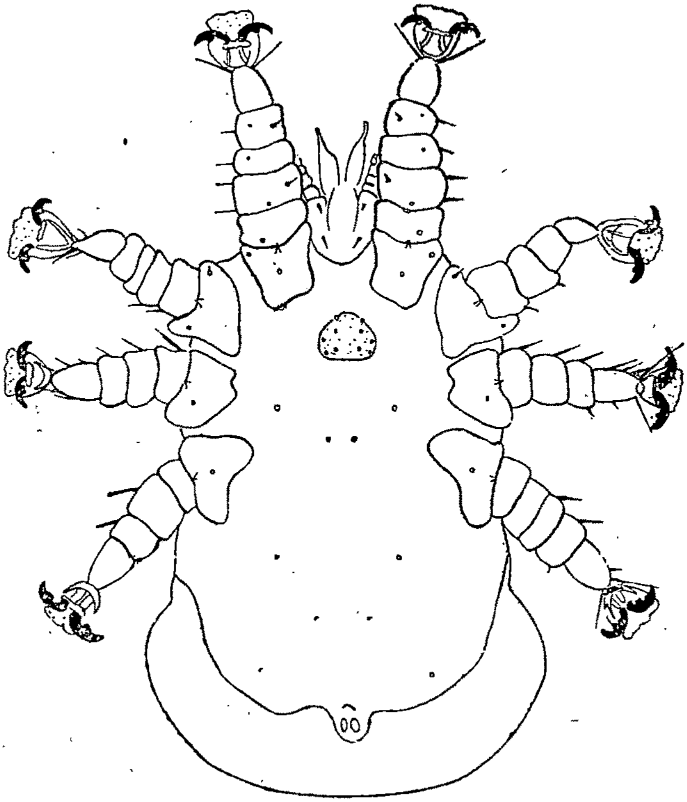


FIG. 137. *Periglischrus rhinolophi.* Ventral view of female.

Legs : Long, with segments distinct and square-cut. Femur and trochanter with characteristic long hairs directed outwards. Tarsus with big claws, humped basally with a large caruncle showing an additional lobe. Inner margin of coxae iv is not so strongly curved.

Male : *Ventral surface. Sternal plate* oval with the anterior end bearing a genital opening and more pointed than the posterior. Its sides in the anterior half clearly visible and in the posterior half faint and indistinguishable. It bears 3 pairs of submarginal and 2 pairs of surface pores. Four pairs of pores, in the propodosomal region, the anterior two pairs in the region of coxa iii and the posterior two in the region of coxa iv. Anal plate with a pair of small spines on the anterior border. Peritremes and legs as in female.

Dorsal surface : The arrangement of platelets mostly as in female and the exact number and shape could not be ascertained on account of their poor chitinization. Eight pairs of median and four to five pairs of lateral pores on the dorsal surface as in female. A single seta in level with coxa iii. Posterior border on either side of anus with a moderately long seta.

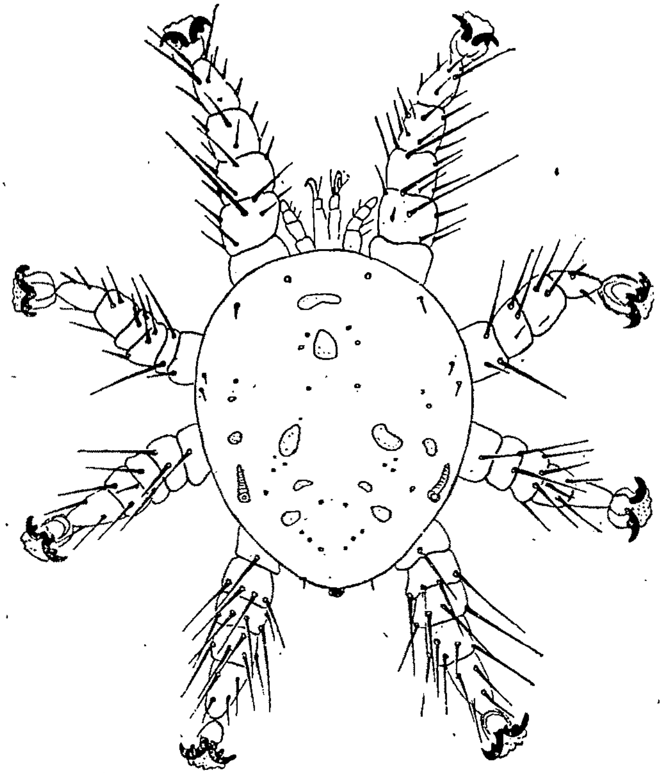


FIG. 138. *Periglischrus rhinolophi.* Dorsal view of male.

Legs and peritremes as in female.

Host.—A horse-shoe bat, *Rhinolophus rouxi* (Temn.) *Locality* : Tulsi Lake Tunnel, Bombay, 1953 and 1954.

B. Family Macronyssidae Oudemans, 1936

This family consists of more than a hundred species of haematophagus mites, ectoparasitic on mammals, birds and reptiles. Of these, about 45 are parasitic on bats, some of which are responsible for the transmission of *Schizotrypanum*, a flagellate parasite, relation of which with man is still doubtful.

The mites of this group were included in the family Dermanyssidae until 1931, when they were transferred to the family Liponyssidae by Vitzthum (1931). In 1936, Oudemans proposed the name Macronyssidae for Liponyssidae which is also followed by Fonseca (1948) in his monograph on these mites. Other Acarologists prefer Liponyssidae to Macronyssidae as it is widely followed.

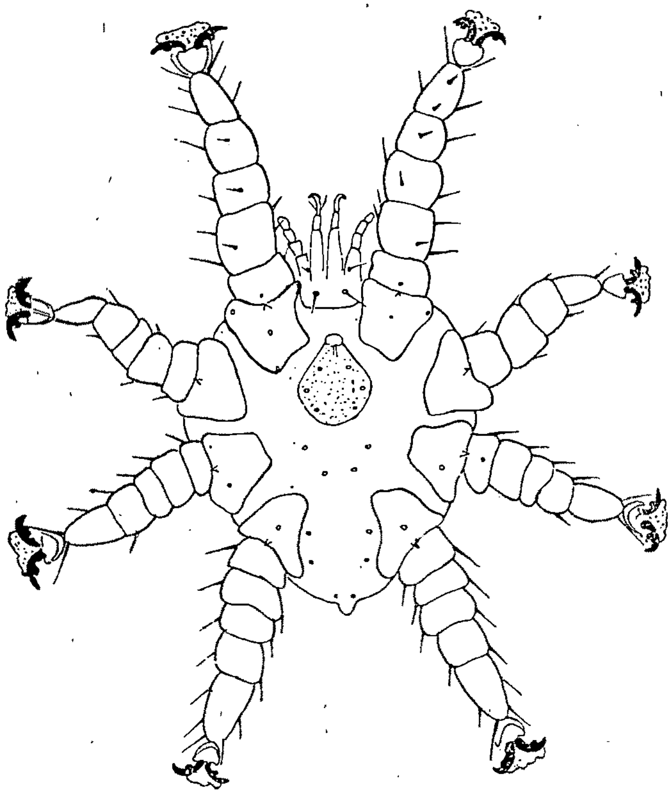


FIG. 139. *Periglischrus rhinolophi.* Ventral view of male.

Genus **Steatonyssus** Kolenati, 1858

About a dozen species are known under this genus and most of them are parasitic on bats. Only one species *S. javensis* is recorded from India (Khandala, Bombay) by Oudemans in 1914.

8. **Steatonyssus hubli,** sp. n.

(Figs. 140-143)

Several specimens of this mite were obtained from a number of house bats at Hubli and Bombay in 1952 and 1953. Along with the adults, the larval and nymphal stages were encountered in large numbers. Females are easily recognised by their large size and usually outnumber the males which are small and not so heavy blood suckers.

The specimens before us differ from *S. javensis* the only representative of this genus on bats from India in having a strongly chitinized posterior margin of the sternal plate. Though they bear some resemblance to *S. joaquimi* Fonseca, 1935 they also differ from it in possessing metasternal plate-lets and an irregular margin of the dorsal and ventral plates in male. In addition the chaetotaxy of the dorsal and ventral plates show variations in both species.

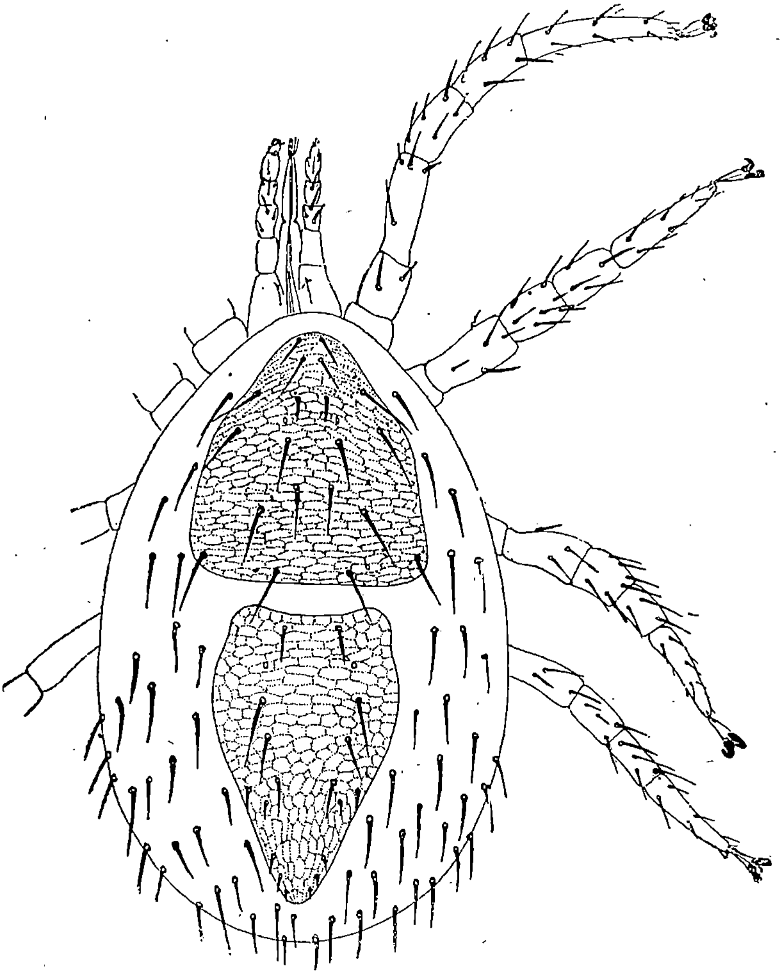


FIG. 140. *Steatonyssus hubli.* Dorsal view of female.

In view of these characteristic differences the specimens from Bombay State are new to science and are named as *Steatonyssus hubli.*

Gnathosoma : Epistoma thin and difficult to identify. In female the chelicerae nearly of the same length. Palps five-jointed, excluding the basal one. First segment i.e. trocanter with a strongly developed spine-like incrassation on the ventral inner margin. Fifth segment of palps with a bifid seta at the base.

Idiosoma : Body ellipsoidal, measuring 0.95 × 0.42 mm. in female and 0.70 × 0.35 mm. in male.

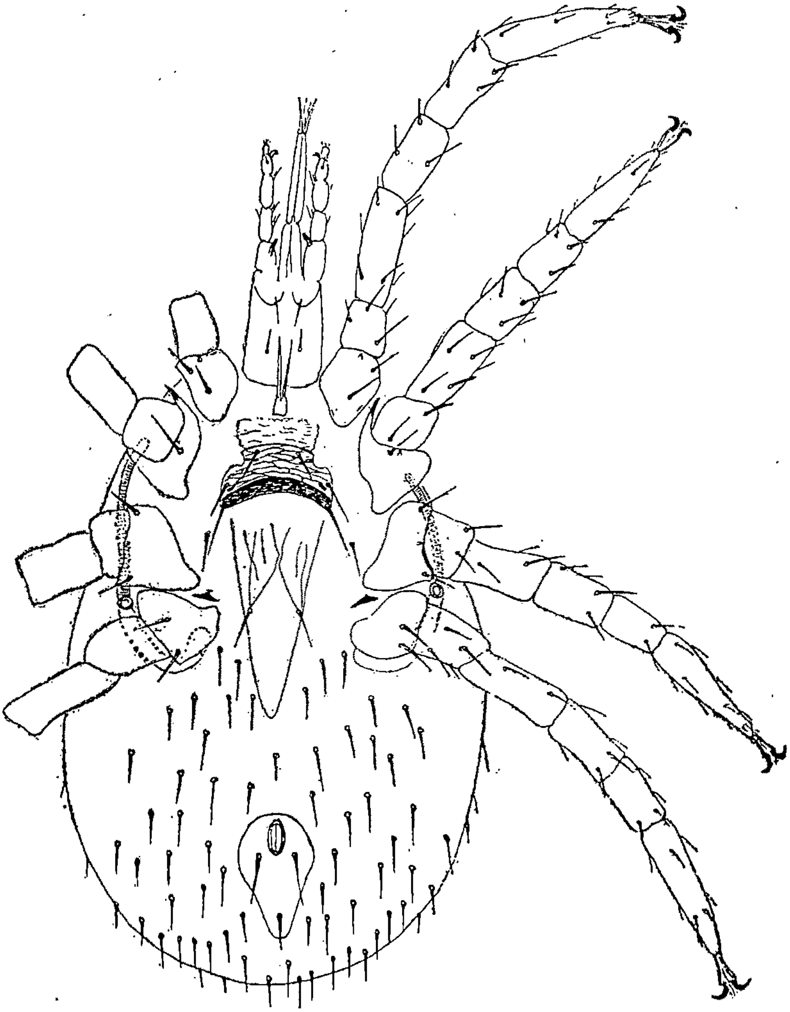


FIG. 141. *Steatonyssus hubli.* Ventral view of female.

Female : Ventral surface - Sternal plate broader than long, with the posterior border thick and concave and the surface with three pairs of sternal spines and two pairs of slit-like openings. Anterior pair of sternal spines placed somewhat close together. Surface reticulated and continuous with the reticulations of the poorly chitinized presternal plate. Tritosternum with a basal portion and an unpaired pilose lacinae. *Genital plate* progressively narrowed posteriorly tapering more or less to a point; as in *S. joaquimi* and the surface showing longitudinal striations. It extends from the genital aperture just behind the sternal plate to the middle of the ventral surface. A single spine towards the lateral margin of the genital plate in level with the 4th pair of coxae. A pair of metasternal platelets placed symmetrically on either side in between the 3rd and 4th pair of coxae. Metasternal platelets absent in *S. joaquimi.* About 50 setae in the opisthosomal region, leaving a small uncovered area behind the 4th pair of legs. Some of these setae on or near the posterior border longer than the rest. Stigmata on the ventral side with an opening near the outer margin of coxa iv, the posterior arm behind the opening curves round the posterior border of coxa iv and the anterior arm of the peritreme running forwards turning dorsally and ending in level with the middle of coxa ii.

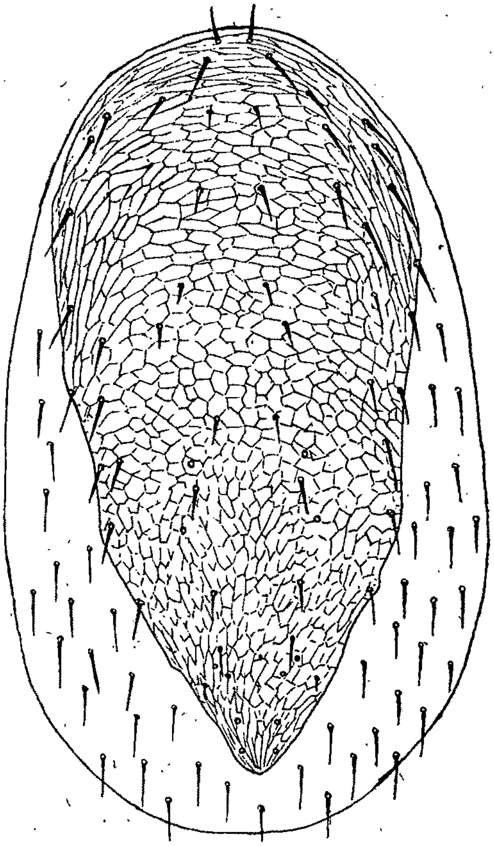


FIG. 142. *Steatonyssus hubli.* Dorsal view of male abdomen.

Dorsal surface : Dorsal plate consists of two plates. Anterior triangular podosomatal plate with the corners rounded, the lateral margins expanded in the middle forming a shoulder and the posterior border slightly concave. Its surface bears 8 pairs of median and 6 pairs of lateral spines. Opisthosomatal plate tongueshaped, smaller than the podosomatal being separated from it anteriorly by a small gap. Its surface bears 6 pairs of median spines, 6-8 pairs of minute punctations near the posterior end and 2-4 punctations with minute spines on or near the lateral margins. Soft integument bordering the podosomal region with 6 pairs of long spines and opisthosomal region with about 50 spines of the same length.

Legs : First pair of legs longer than the 2nd, 3rd and 4th. Second and third pairs nearly of equal length and the 4th pair a little longer than the 2nd and 3rd . Coxa i roughly hexagonal bearing 2 spines and coxa ii with a spine in the anterior augle.

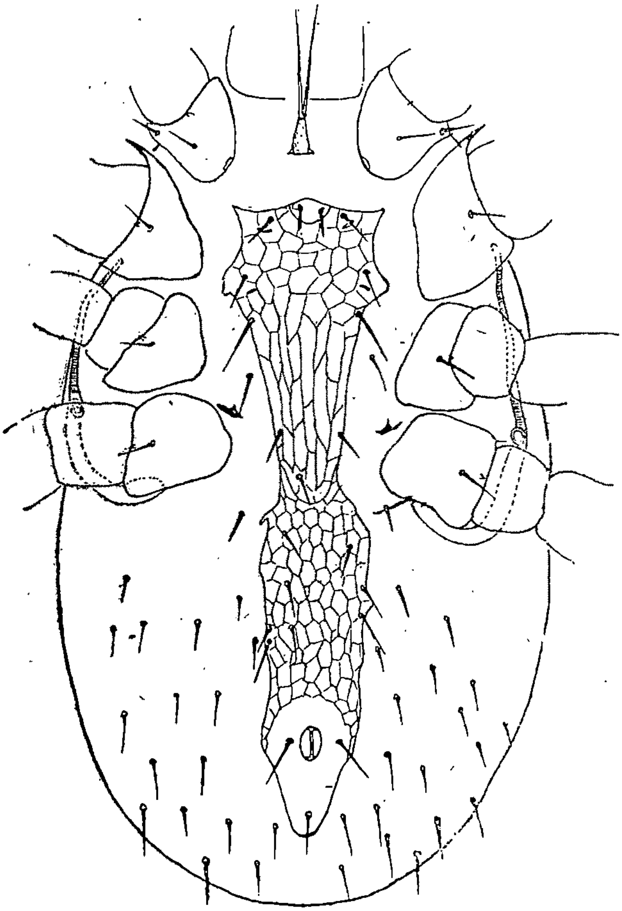


FIG. 143. *Steatonyssus hubli.* Ventral view of abdomen of male.

Male : Ventral surface. Holoventral shield entire, not divided, widest in the region of the sternal plate and its anterior corners produced into an angle. Male genital opening situated anteriorly being flanked on either side by a pair of sternal spines and followed by a pair of slit-like openings. Lateral margins wide and irregular at the region of the 2nd pair of spines and the posterior pair of slit-like sternal opening. Third pair of sternal spines situated in level with coxae iii. Sternal plate region reticulated as in female while the genital plate region longitudinally striated. Holoventral plate narrow bearing a pair of genital spines in between coxa iv. Posteriorly the holoventral plate expanded, narrowing towards the posterior end. Lateral margin in this region irregular. The region of the plate anterior to the anus and posterior to the genital spines bears 5-6 moderately long spines. Anal plate as usual with 3 spines, two on either side and one posterior to the anal opening. Metasternal spines situated in level with coxa iii and metasternal plate lets near the inner border of coxa iv. Opisthosomal region, flanking on either side of holoventral plate bears about 30 spines, uniformly distributed and shorter than those found on the dorsal urface. Presternal plate poorly chitinized.

Dorsal surface : Dorsal plate single, egg-shaped, covering practically the whole of dorsal surface. Its anterior end broadly rounded, the posterior slightly pointed and the sides rather irregular. Surface striated and studded with about 15 pairs of small median and about 12 pairs of lateral spines. Lateral spines little longer than the median. The rest of the dorsal surface membranous being covered with more than 50 long spines. Peritremes as in female.

Host.—A house-bat, *Pipistrellus ceylonicus chrysothrix* (Blyth). *Locality* : Carla Caves Poona and Hubli (Bombay State) in 1952 and 1953.

Genus **Ichoronyssus** Kolenati, 1858

About 18 species are known under this genus and many of them are found on bats. So far this genus has not been represented from bats of India.

9. **Ichoronyssus lingaraji,** sp. n.

(Figs. 144-146)

About a half dozen specimens were obtained from *Taphozous longimanus*, Belgaum, in 1954. They show some similarity to *Ichoronyssus kochi* Fonseca, 1948 but differ from it in the shape of the dorsal plate in male and the shape of the sternal plate in female. In these specimens under discussion the dorsal plate has a constricted portion posteriorly while in *I. kochi* it is broad. Moreover the sternal plate is poorly chitinized, bearing a well developed presternal plate which is absent in *I. kochi.* Hence these specimens have been described here under a new species *Ichoronyssus lingaraji.*

Idiosoma : Body oval when fully engorged. Female 0.93 × 0.42 mm. and male 0.75 × 0.45 mm.

Female : Ventral surface. Sternal plate broader than long, without any prolongations and measure 0.14 mm. at its widest length. Posterior border more concave than the anterior. Surface with transverse reticulations anteriorly merging with the presternum. Prolongation on the antero-lateral corners slight. Three pairs of sternal spines and two pairs of slit-like opening on the sternal plate, the anterior pair of sternal spines being situated near the anterior border in front of the first pair of slit-like opening and the other two pairs marginal. *Presternal* plate clear and reticulated. Metasternal platelets absent but instead metasternal spines present. *Genital plate* longer than broad, measuring 0.26 mm. long and 0.066 mm. in width at the level of a single pair of marginal genital spines and narrowing gradually to form a point situated a short distance behind coxa iv. Its surface poorly reticulated with longitudinal lines. Anal plate with a pair of setae placed in level with the posterior border of the anal opening. Rest of the ventral surface covered with about 70 rigid long and blade-like spines. Stigmata placed in level with coxa iii and peritremes run dorsally upto coxa i.

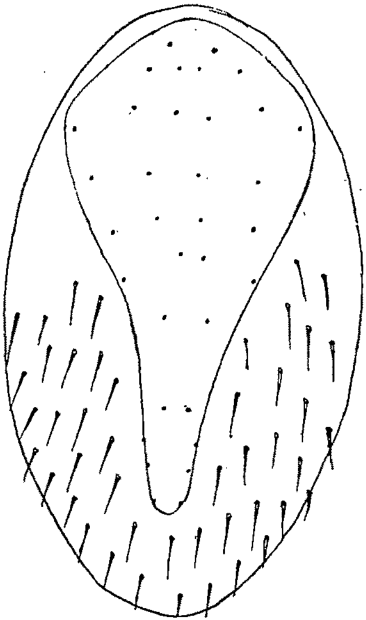


FIG. 144. *Ichoronyssus lingaraji.* Dorsal view of abdomen of female.

Dorsal surface : Dorsal plate single, longer than broad measuring 0.56 x 0.29 mm. in the holotype, with the posterior portion attenuated to form a blunt process. Its surface reticulated with numerous transverse striations and covered with about 25 moderately long setae arranged in pairs medially and laterally. Uncovered portion of the dorsal surface studded with 30-35 strong setae having blunt tips.

Male : Ventral surface. Holoventral plate entire, without any clear line of demarcation between the various plates and expanded in the region of the sternal plate between coxae iii. Anterior margin produced laterally between coxae i and ii. Three pair of spines in the sternal plate region nearly of equal length and the 4th pair behind them slightly longer than the sternal. Surface with clear reticulatons bearing twopairs of slit-like sternal openings anteriorly. Fifth pair of setae shorter than the 4th and situated between the 4th pair of coxae. Posteriorly behind the 4th pair of legs the ventral plate bears 5 spines in the region anterior to the anal plate. Anal plate as in female. Region outside the ventral plate studded with about 20 long setae smaller than those found dorsally. Peritremes as in female.

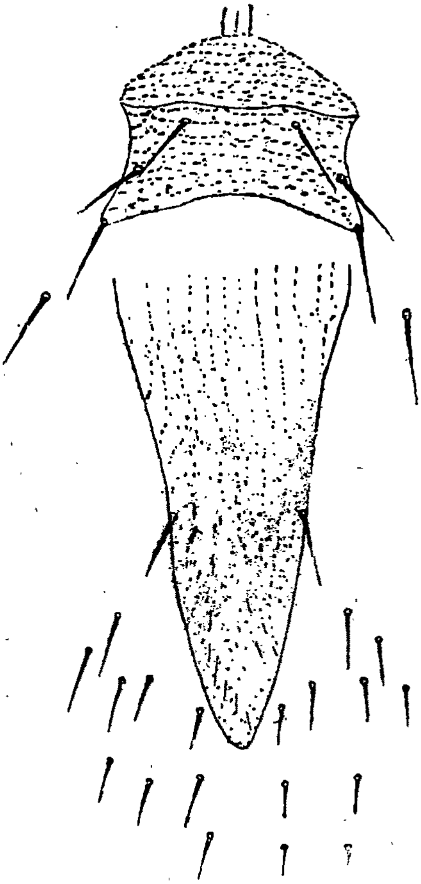


FIG. 145. *Ichoronyssus lingaraji*. Sternal and genital plate of female.

Dorsal surface. Dorsal plate similar to that of female and the soft integument bears a few setae.

Legs as in female.

Host.—A *Taphozous longimanus* (Hardw.) *Locality :* Lingaraj College Building, Belgaum, 1954.

Genus **Hirstesia** Fonseca, 1948

This genus is characterised by two window-like openings on the sternal plate and it includes *Hirstesia sternalis*, *H. transvaalensis* and *H. kenyansis*. Of these the first one is reported from Palaearctic Region and the other two from Africa. Fonseca (1948) created another genus *Lepronyssoides* closely related to *Hirstesia* from Nearctic Region but it differs from the latter in the possession of a single pair of setae instead of three on the genital plate.

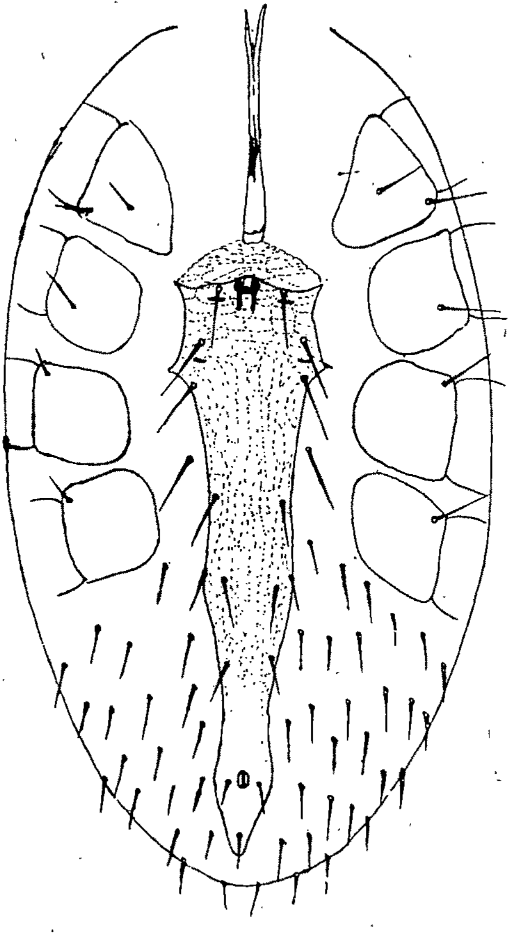


FIG. 146. *Ichoronyssus lingaraji.* Ventral view obdmen of male.

10. **Hirstesia transvaalensis** Zumpt. 1950.

A few specimens of this mites were collected along with those of *Spinturnix psi* from Mahabaleshwar in 1953. They resemble *H. transvaalensis* from Transvaal South Africa, in some respects but differ from it in the shape of the dorsal plate and the circular openings on the sternal plate. In the specimens before us the dorsal plate tapers gradually and is not abruptly narrowed posteriorly so as to form a tail-like process as in *H. transvaalensis*. In addition the circular openings on the sternal plate are comparatively larger and the peritremes extend upto the middle of coxa i.

C. Family Laelaptidae Berlese, 1892

The family Laelaptidae includes a group of mites some of which are non-parasitic and the others parasitic on lower and higher animals. Only two genera viz. *Neolaelaps* and *Spinolaelaps* are parasitic on bats. They are characterised by two times on the specialised seta of the palpal tarsus. The epigynal plate is drop-shaped or excavated posteriorly and the peritremes elongated. The dorsal plate is undivided.

Genus **Neolaelaps** Hirst, 1926

Only two species *N. echinnis* and *N. magnistigmatus* are known under this genus. Of these the last one has been reported from a few places in the Oriental Region, though for the first time from India.

11. **Neolaelaps magnistigmatus** Vitzthum, 1918.

Over a dozen specimens of this mite were collected from *Pteropus giganteus giganteus* from Bombay, Poona & Lucknow in 1952 and a thorough examination of these specimens revealed that they agree with the original description of the species from Batavia. This is the first record of this species from India.

This species has previously been recorded on *Pteropus edulis* and *Talpa europea*, Batavia, in 1918.

D. Family Myobiidae Megnin, 1877

Carl von Heydon (1826) established the genus *Myobia* for a bat mite, naming it, as *Myobia coarctata*. Subsequently many more species have been added to it, from the Chiroptera, Insectivora and Rodentia. The main character of this genus is the modification of the first pair of legs into a hair clasping organ. Megnin (1877) established the family Myobiidae and about 80 species have been so far recorded under different genera mentioned below.

Ewing (1938) was the first to provide a key to all the genera of this family known at that time and subsequently Radford (1948) gave a key for seven genera. Recently Jameson (1952) has added four more genera to this family and hence an attempt is made here to frame a key to all the eleven genera of the family Myobiidae.

A KEY TO THE GENERA OF THE FAMILY MYOBIIDAE

1. Leg i with 3 segments. Capitulum with a hook-like process. ... ... *Calcaromyobia* Radford 1948
   Leg i with 3 or more segments. Capitulum without a hook-like process. 2
2. Leg i with 3 or 4 segments and without claws 3
   Leg i with 5 segments and with 1 or 2 claws 8

3.	Leg ii with 1 claw	*Myobia* v. Heyden, 1826
	Leg ii with 2 claws	 4
4.	Capitulum asymmetrical. Leg i unequal ...	*Amorphacarus* Ewing, 1938.
	Capitulum symetrical. Leg i equal ...	 5
5.	Dorsal spines foliate	*Foliomyobia* Radford, 1948.
	Dorsal spines not foliate	 6
6.	Lateral spines paired ...	*Ewingana* Radford, 1948
	Lateral spines single	 7
7.	Legs iii and iv with 2 claws	*Eutalpacarus* Jameson, 1949.
	Legs iii and iv with 1 claw	*Radfordia* Ewing, 1938.
8	Dorsal spines completely or partially foliate	 9
	Dorsal spines not foilate	 10
9.	Dorsal spines mostly foliate. Penis thick, not forming a loop.	*Neomyobia* Radford, 1948.
	Dorsal spines partially foliate. Penis slender, forming a loop....	*Eadia* Jameson, 1949.
10.	Legs iii and iv with 2 claws. Penis slender	*Pteracarus* Jameson, 1952.
	Legs iii and iv with 1 claw. Penis thick	*Protomyobia* Ewing, 1938.

Genus **Foliomyobia** Radford, 1948

Only 3 species of this genus were known so far and one more new species is added here from India. All are parasitic on bats.

12. **Foliomyobia barnleyi** Radford, 1951

Radford (1951) described this species from an unknown bat at Kampala, Uganda. It is characterised by 4 pairs of lateral and 6 pairs of median foliate spines on the dorsal surface in the female and 3 pairs of large and 2 pairs of small foliate spines in the male. The penis is somewhat thick and with a single loop.

A single bat from a roof of the Bombay Veterinary College, was found infested with *Foliomyobia barnleyi*. This is the first record of this species from India and the host is *Taphozous longimanus*.

13. **Foliomyobia jamesoni,** sp. n.

(Figs. 147-148)

A few specimens of Myobiid mites were obtained from a frugivorous bat at Kanheri Caves, near Bombay in 1953 and they were assigned to the genus *Foliomyobia,* on account of the first pair of legs with 3 segments, the tarsus without any claw and the capitulum without any process.

Out of the 3 species reported previously under the genus *Foliomyobia* the present specimens resemble *Foliomybia barnleyi* to some extent but they differ from it, in possessing a pair of short spines between the median spines VII on the dorsal surface and by the absence of many short spines on the ventral surface.

On account of these two differentiating features, the specimens under discussion are here described as new to science and are named as *Foliomyobia jamesonia* after E. W. Jameson of California for his valuable help.

Idiosoma : Body much longer than broad. Female - 0.65 - 0.75 mm. long (including the 1st pair of legs).

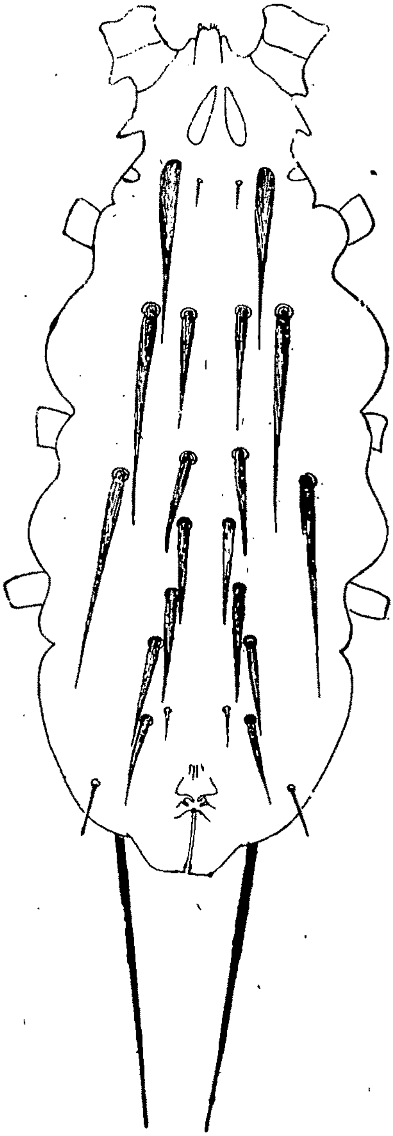


FIG. 147. *Foliomyobia jamesoni.* Dorsal view of female.

Female : Dorsal surface. Lateral spines I broadly foliate at the base, tapering gradually towards the tip, situated anterior to leg ii and its tip extending beyond the base of the succeeding lateral spines. Lateral spines II longer than the 1st, broader at base, tapering towards the tip and placed midway between legs ii and iii. Its tip extending beyond the base of lateral spines III. Lateral spines III also foliate, as long as the 2nd and placed in level with the posterior border of the leg iii. Lateral spines IV small, not foliate and situated on either side of the genital pore. Median spines I very small, not foliate and placed a little posterior to the base of lateral spines I. Median spines II foliate, shorter than the lateral spines II and situated in level with them. Median spines III, as long as the 2nd median spines and placed in level with coxa iii. Median

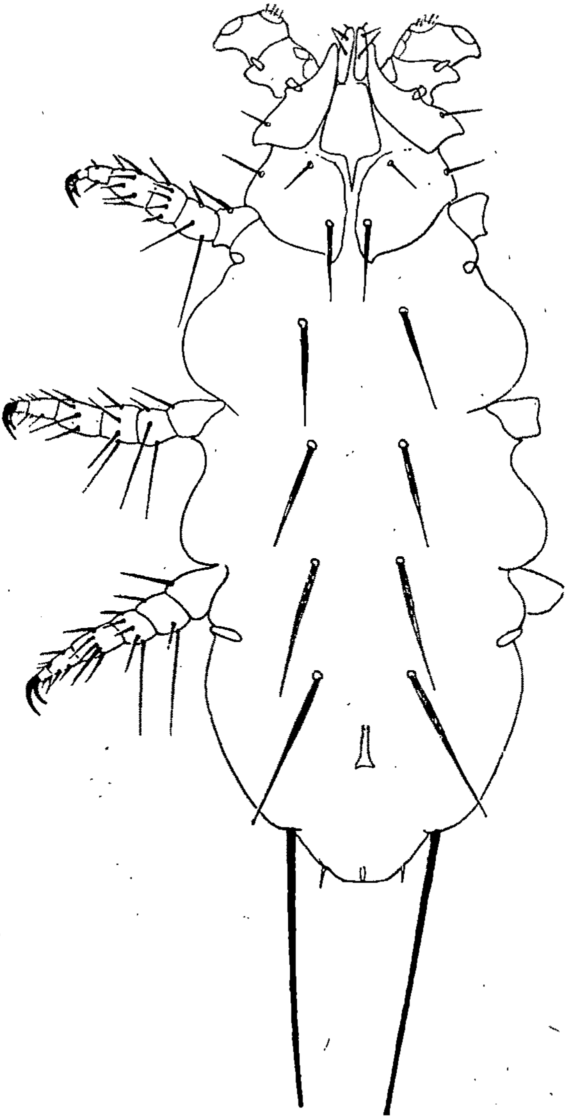


FIG. 148. *Foliomyoblia jamesoni.* Ventral view of female.

spines IV midway between legs iii and iv. Median spines V situated in level with coxa iv. Median spines VI and VII, a little apart than the anterior median pairs and situated in the opisthosomal region. A pair of small spines in between the median spines VII.

Ventral surface : A pair of small spines behind the 1st pair of coxae and another pair of moderate length between coxe ii. A third pair of long spines situated midway between 2nd and 3rd pair of legs and the tip extending beyond the 3rd pair of legs. In addition two more pairs of equally long spines in level with the posterior border of coxa iii and in between coxa iv. Opisthosomal region with a pair of equally long spines whose tip extending beyond the posterior border of the body. Terminal bristles very long, stout, as long as the length of the whole body. Posterior border of the abdomen with a short spine lateral to the anus.

Legs : First pair of legs 3-segmented with very small bristles dorsally. Ventrally the surface of 2nd and 3rd pair of legs provided with 2 short, thick spines for clasping. Bristles on the remaining legs long and tarsi of 2nd, 3rd and 4th pair of legs with 2 unequal claws.

Male not known.

Host.—A frugivorous bat, *Rousettus leschenaulti* (Desm.). *Locality* : Kanheri Caves Bombay, 1953.

Genus **Neomyobia** Radford, 1948

About a dozen species are known under the genus *Neomyobia.* Most of the species are recorded from Ethiopian and Palaearctic Regions. A record of *N. tulsi* sp. n. has been made for the first time from India.

14. **Neomyobia tulsi** sp. n.

(Figs. 149-152)

A large series of specimens of this species were collected from *Rhinolophus rouxi*, Tulsi Lake Tunnel, Bombay, in 1953 and 1954. This species resembles *Neomyobia africana* Lawrence, 1951, but differs from it in the absence of paired median spines between the lateral spines I and the peculiar, conspicuous, pore-like openings ventrally, in the opisthosomal region of the female. It also differs from that species, in having a median pair of foliate spines bordering the genital opening in male.

Idiosoma : Body longer than broad. Female 0.5-0.6 mm. and male 0.42-0.5 mm. in length (including the palps).

Female : Dorsal surface. Lateral spines I broadly foliate, abruptly pointed, situated between coxae i and extend upto the middle of the succeeding lateral spines. Lateral spines II not so broadly foliate but tapering posteriorly towards the tip and situated a little anterior to the middle of the region between coxae ii and iii, in line with the median spines I. Its tip extending upto the anterior border of the 3rd pair of legs. Lateral spines III somewhat longer than the proceeding pair, foliate, tapering gradually towards the tip and situated between coxae iii, posterior to the median spines II. Median spines I broad, foliate at base, placed in level with the lateral spines II and extend upto leg iii. Median spines II like the first, placed between leg iii and extend

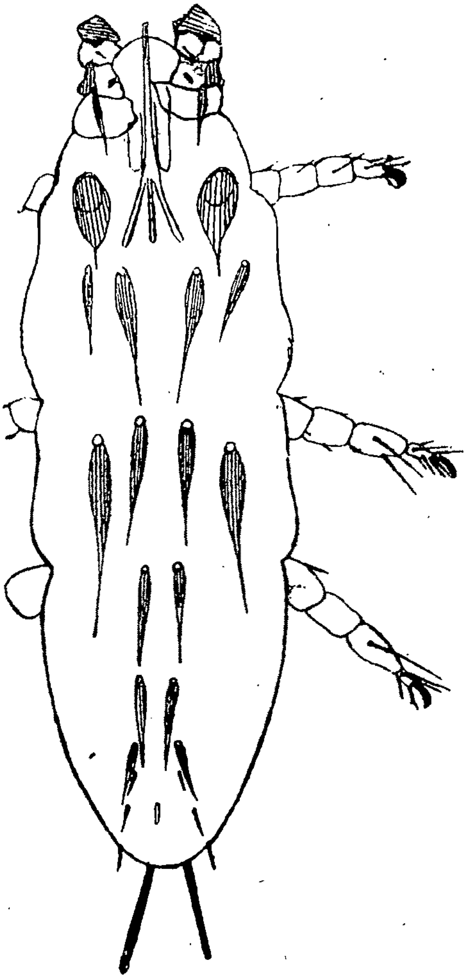


FIG. 149. *Neomyobia tulsi.* Dorsal view of female.

upto leg iv. Posteriorly, three pairs of median spines foliate and small. Of these three pairs, one pair situated between legs iv and the other two placed behind a little anterior to the anus. Three pairs of non-foliate minute spines posterior to the foliate spines, the anterior pair situated in front of the anus, the middle pair in level with the anal opening and the posterior pair behind the anal opening near the margin.

Ventral surface : A pair of small spines behind leg i. Three pairs of short spines midway between coxae ii and iii. Of these the posterior pair longer than the two anterior minute ones. A pair of long spines anterior to coxae iv, extending upto the middle of the region behind coxa iv and the posterior margin of the body. Another pair of long spines shorter than the previous pair separated widely and placed in the middle of the opisthosomal region. A pair of exceptionally long spines on the hind border.

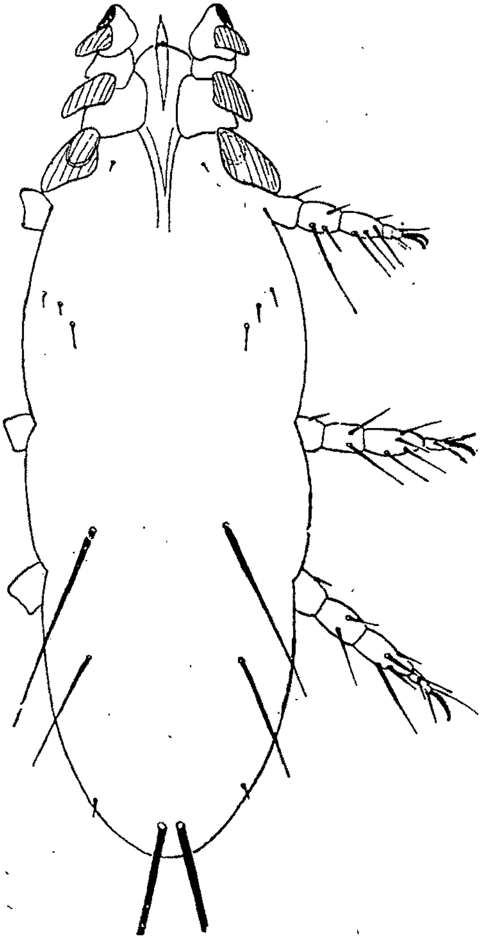


FIG. 150. *Neomyobia tulsi.* Ventral view of female.

Legs : First pair of legs five-segmented, the 1st segment having a claw for clasping the hair. Second segment of leg i with a moderately long foliate spine tapering gradually towards the tip extending upto the anterior border of lateral spines I. Another short spine towards the inner border. Ventrally 1st pair of legs with 3 pairs of winged spines on the 1st, 2nd and 4th digits respectively. Of these the posterior one much expanded than the other two. Legs ii, iii and iv bear a few short spines dorsally and the ventral surface with short, thick and blunt spines near the anterior margin and long, pointed ones near the posterior border. Claws in female 2-1-1 on legs ii, iii and iv respectively.

Male : Dorsal surface. Lateral spines I broad, foliate, abruptly tapering, situated anterior to legs i and extend upto the anterior border of coxa iii. Lateral spines II also foliate but not so much expanded as the 1st, situated between coxae ii and extend upto midway between the 3rd and 4th pair of legs. Lateral spines III broadly foliate, situated between coxae iii and extend upto the middle of the opisthosomal region. A pair of very smalls pines in the median region between the lateral spines I and another pair of the same length in level with the lateral spines II but placed near the base of the spines. Median spines III and IV foliate, smaller than the laterals. Of these the 3rd pair placed in the middle of the coxae ii and iii, rather close to the genital opening, its tip extending beyond the base of lateral spines III. Median spines V long, not so much expanded and placed midway in the opisthosomal region and extending nearly to the posterior border of the abdomen. A pair of small foliate spines

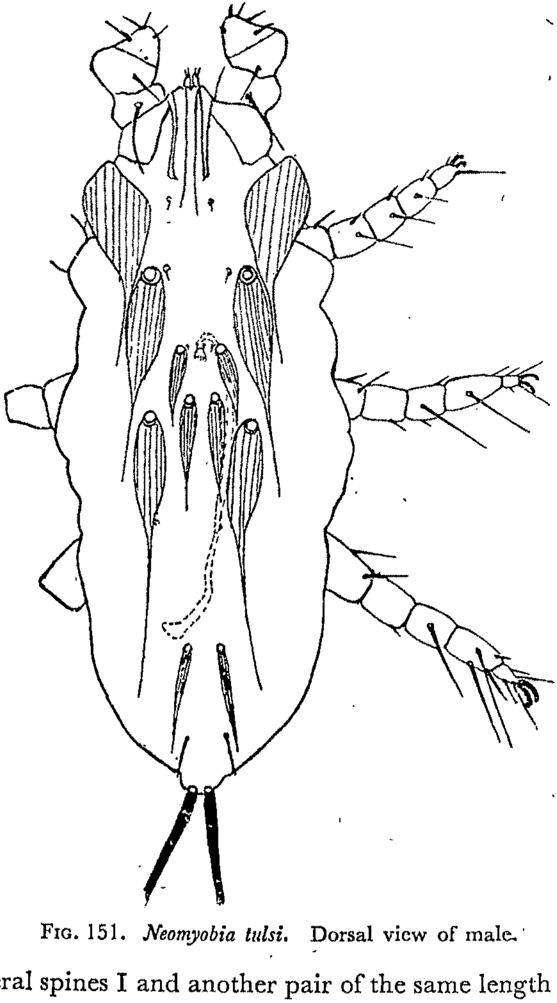


FIG. 151. *Neomyobia tulsi.* Dorsal view of male.

posteriorly. Two long whip-like spines on a bilobed structure, as long as the length of the body. Penis long, tapering gradually and not looped but only curved distally.

Ventral surface : Two short spines on either side, a little anterior to the 2nd pair of legs and two still shorter ones rather closely placed medially between coxa ii. Lateral spines in the region between coxae ii and iii very small. Median pair situated in level with them long, extending upto the middle of the region between coxae iii and iv. Two long spines rather far apart, nearly to the middle of the opisthosomal region extend midway between coxae iii and iv. Two long posterior spines placed in level with the posterior border of coxae iv the tip of these spines extending beyond the margin of the posterior border. Lateral margin, behind the 2nd pair of legs with a long slender spines.

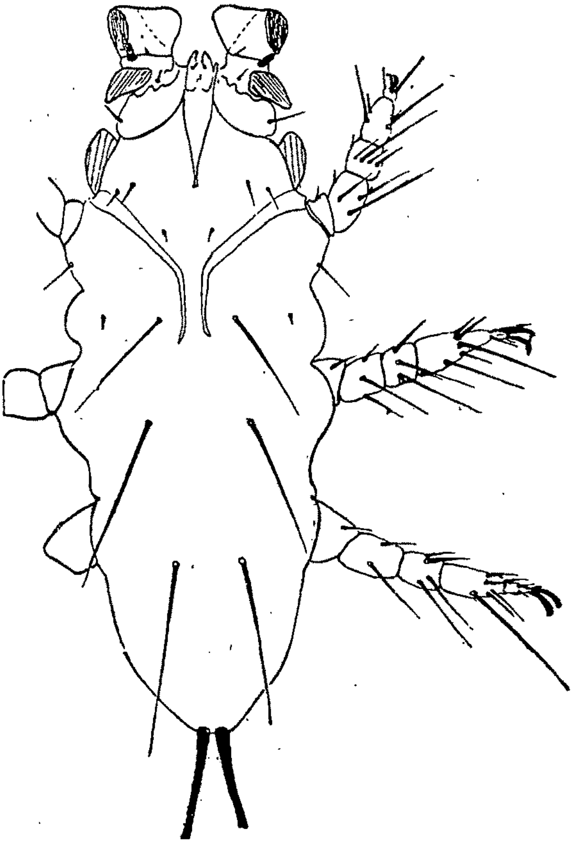


FIG. 152. *Neomyolia tulsi.* Ventral view of male.

Legs : Leg i five-segmented as in female but the distal segment more expanded. Dorsally, a moderately long spine on digit ii as in female. Ventrally 1st pair of legs with a wing-like expansion. Two claws on legs ii,iii and iv, the 2nd tarsus having a large and the other two tarsi with equal claws.

Host —Horse-shoe bats, *Rhinolophus rouxi* (Temn.) *Locality* : Tulsi Lake Tunnel, Bombay, 1953-1954.

E. Family Trombiculieae Ewing, 1944

The Trombiculids are external parasites of vertebrates as well as invertebrates during their larval stage. Many of them are a source of extreme annoyance to man. They produce "itch" and their association with a typhus like disease in man has been established since long.

The classification of Trombiculid mites is based on their larval stage. This family was first created by Ewing (1944) and is now divided into four subfamilies viz. Trombiculinae, Leeuwenhoekinae, Hemitrombiculinae and Walchinae with 38 genera and more than 380 species occuring throughout the Asiatic-Pacific Region. Some species have been recorded in India, particularly, from Assam, Kashmir and other isolated places, mainly found on rodants. Of these *Trombicula schmitze* and *T. hirsti* are known so far from Indian bats.

Genus **Whartonia** Ewing, 1944

Four species, of which one is from bats, have been recorded till now. One new species is described here from Bombay bats; and is the first record of this genus from India.

15. **Whartonia brennani**, sp. n.

(Figs. 153-156)

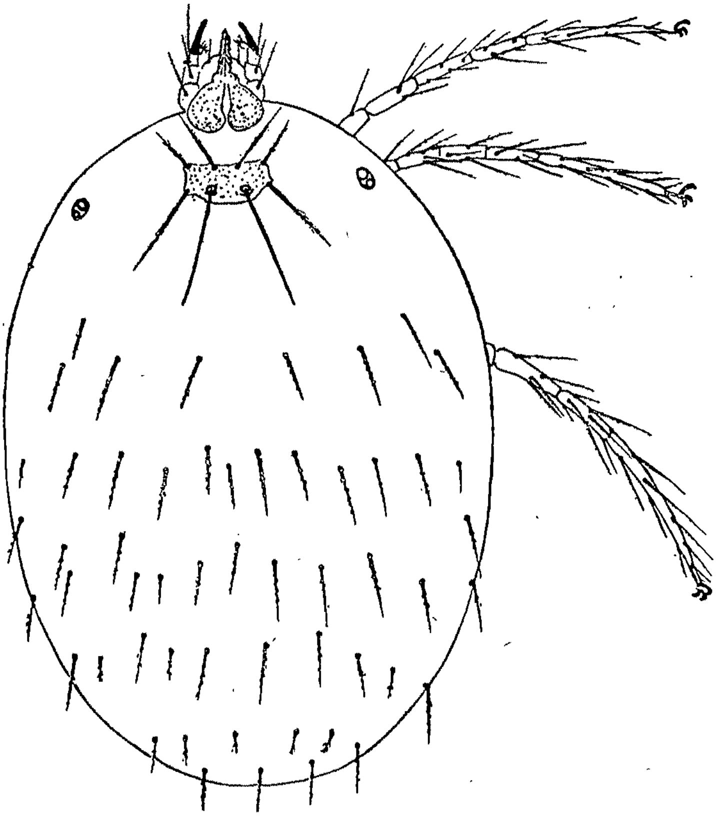


FIG. 153. *Whartonia brennani.* Dorsal view of larva.

About a dozen specimens were collected from horse-shoe bats at Carla Caves near Poona, in 1952. These specimens resemble in some respects *Whartonia* (*Hannemania*) *perflexa* Brennan, 1947, also recorded previously from bats. They differ however from it chiefly in having the scutum much broader with concave sides and the chelicerae narrow with strong recurved teeth. The present specimens are, therefore, treated here as new to science and are named after Brennan of Montane his kind help on this group of bat parasites. This speecies is tentatively assigned to the genus *Whartonia*, although it is not a true *whartonia* because of the absence of spiracles and tracheae.

Description of larva

Body oval. Colour white. Length : 1.0 - 1. 4 mm. and breadth 0.7-0.8 mm.

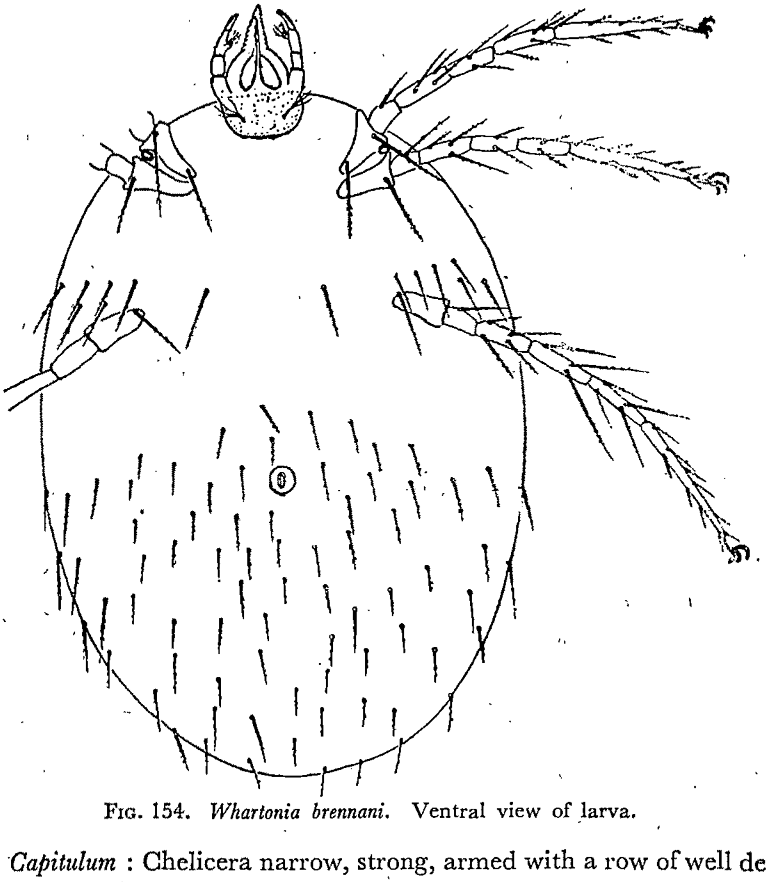


FIG. 154. *Whartonia brennani.* Ventral view of larva.

Capitulum : Chelicera narrow, strong, armed with a row of well developed recurved teeth. Base of the capitulum slightly longer than broad and heavily punctate dorsally. Capitulum ventrally broader than long, punctate with two slender hairs divided into 4 branches, near the base. Cheliceral setae long and without any branching. Palpal claws with three or more prongs. Thumb longer than broad with 5-6 setae and a short spur. Branching of these setae inconspicuous.

Dorsal surface : Scutum - about two times as wide as long with no antero-median projection. Marginal setae six in number, consisting of two antero-median, two antero-laterals and two postero-laterals, fine and plumose. Sensillae flagelliform, slender than the marginals, delicately plumose in the distal half with the bases separated by a little more than the distance between the antero-laterals and postero-laterals and located slightly posterior to the postero-laterals. Surface of the scutum punctate.

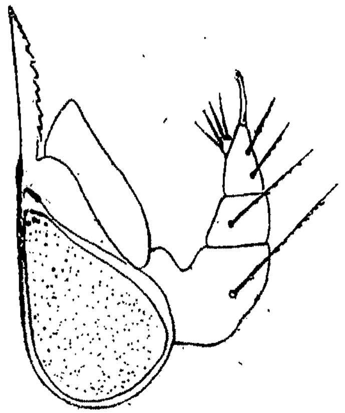


FIG. 155.

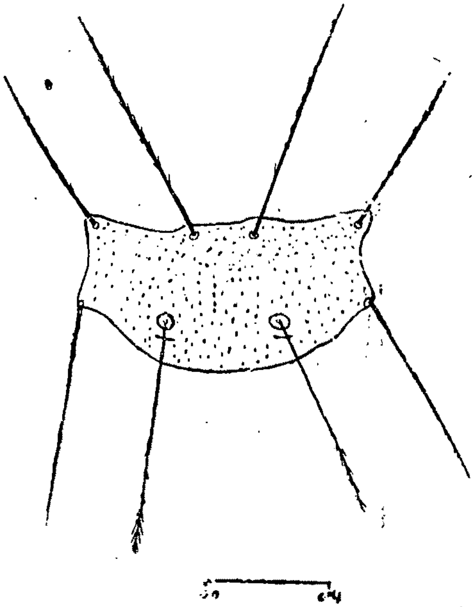


FIG. 156.

FIG. 155. *Whartoni brennani.* Dorsal view of capitulum.
FIG. 156. *Whartonia brennani.* Scutum.

Eyes 2/2 without a circular plate. Dorsal setae about 40 in number arranged in irregular rows, varying in length with no gradient between the anterior and the posterior ones. Branching of setae short and appressed.

Ventral surface : Ventral setae about 60 in number, shorter than the dorsal and not arranged in rows. Of these, six or more placed anterior to coxa iii. Two sternal setae placed far apart, on either side of the middle line. Remaining setae on the venter situated posterior to the anus and a few anterior to it, True well defined spiracular opening situated between the bases of coxae i and ii.

Legs fairly long and slender. Coxal setae 2-1-1.

Standard measurements of the holotype in microns. AW 100, PW 112, SB 44, ASB 30, PSB 15, AP 30, AL 60, AM 96, PL 94, Sens 98.

Host.—A *Hipposidoros bicolor fulvus* (Temn.). Locality : Carla Caves, Bombay State, in 1952.

Genus **Trombicula** Berlese, 1905

The genus *Trombicula* is characterised by the scutum with five normal setae and the palpal claws bi-or trifurcate. It consists of more than 80 species recorded from different parts of the world including about a dozen from India.

16. **Trombicula hampii,** sp. n.

(Figs. 157-161)

About a dozen examples of this species were obtained from *Rhinophoma hardwicki* at Hampi, Mysore State, in 1954. These specimens bear close resemblance to *Trombicula laveri* Womersley, 1952 in the shape of the scutum, the scutal setae ciliated and the claws trifurcate. But they differ from it, in possessing punctations on the scutum, the sensillary bases not midway between the antero and postero-lateral setae and in the standard measurements. They also differ from *Trombicula schmitze* Oudemans, 1914, the only authentic record from Bombay State in having a broader scutum with concave sides, the claws trifurcate instead of bifurcate and by the absence of porous disks behind coxae iii.

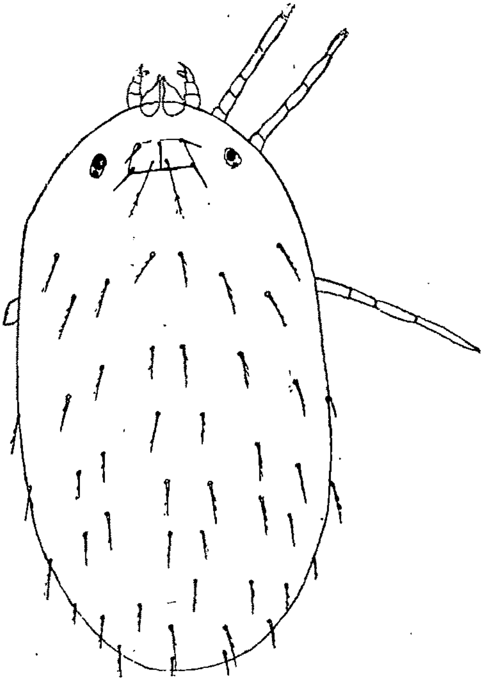


FIG. 157. *Trombicula hampii.* Dorsal view of larva.

Description of larva

Body oval to cylindrical. Colour reddish-brown in life. Length when engorged 0.65 - 0.68×0.32 - 0.36 mm.

Capitulum : Chelicera with a proximal, robust, supporting base and a distal heavily sclerotized, blade-like structure and terminating in one or more teeth. Galea broad bearing a single nude antero-lateral seta. Base of chelicera smooth and not punctate. Chelicera with a tricuspid cap. Palps five-segmented, the first segment fused dorsally and ventrally with a plumose seta. Palpal segment 2 large, usually laterally bowed with a dorsal seta ciliated on one side.

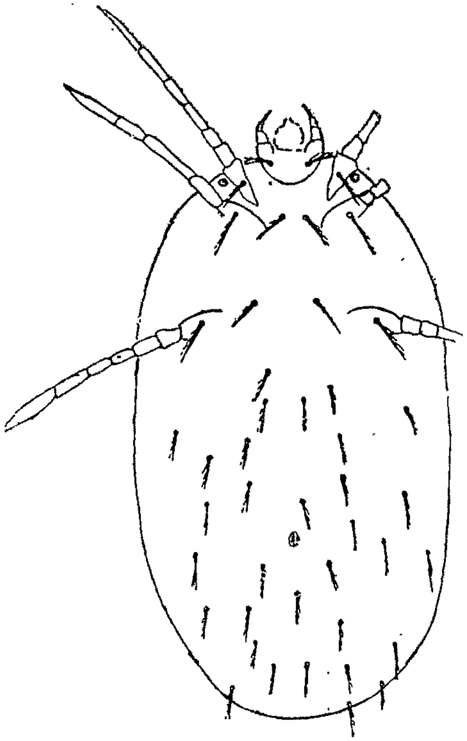


FIG. 158. *Trombicula hampii.* Ventral view of larva.

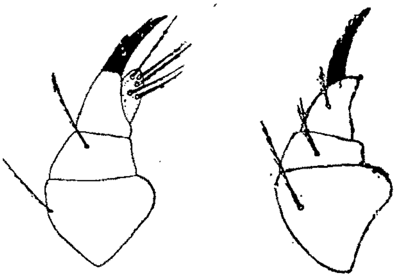


FIG. 159.

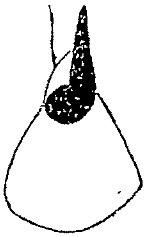


FIG. 160.

FIG. 159. *Trombicula hampii* . Dorsal and Ventral view of palp.
FIG. 160. *Trombicula hampii* Chalicera.

Palpal segment 3 with a similar dorsal seta. Palpal segment 4 with 3 branched setae, one on each dorsal, ventral and lateral sides. Palpal segment 5 with a palpal thumb bearing 4-5 branched setae. Claws with three apical teeth.

Dorsal surface : *Scutum* relatively small, roughly rectangular, wider than long with the margins nearly straight and not so distinct unless stained. Poster -

ior border longer than the anterior. Surface of the scutum punctate but more so in the middle and the anterior portions. Scutal setae marginal. Antero-lateral setae somewhat thick and plumose on one side. Antero-median seta slender than the antero-laterals and plumose. Posterolateral setae thicker than the antero-laterals, more or less of the same length and plumose. Sensillae very long, slender bearing 5-7 branches in the distal half. Distance between the antero-lateral and postero-lateral setae more than the distance between the bases of the sensillae.

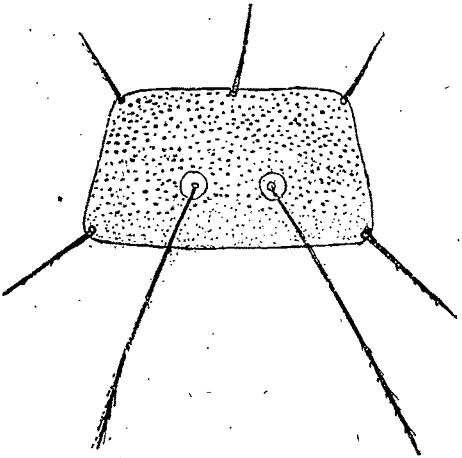


FIG. 161. *Trombicula hampii.* Scutum.

Eyes single (probably the other seems to be very minute and inconspicuous) and located in between the scutum and the lateral margin of the body. Cornia or occular plate absent.

Dorsal setae arranged in a more or less regular transverse rows and branched. Humeral setae absent. Eight setae arranged into two definite rows, in level with and in front of the 3rd pair of coxae. Posterior rows arched consisting of about 25 ciliated setae measuring 30 microns in length.

Ventral surface : A pair of ciliated setae between coxa ii. Another pair of setae, rather closely placed, in level with the anterior border of coxa iii. Setae on the ventral surface shorter anteriorly than posteriorly, about 40 in number, not arranged in any definite rows measuring 25 microns in length.

Legs : Legs strongly developed having 7 segments. Coxae i, ii, iii with 1-1-1 ciliated setae respectively. Setae on legs strong and branched. Terminal claw of all legs with a long fine claw-like empodium.

Standard measurements of the holotype in microns. AW 60, PW 75, SB 22, ASB 32, PSB 8, A-P 30, AL 25, AM 30, PL 36, Sens 56.

Host.—Rhinophoma hardwicki (Grey) *Locality :* Hampi, Hospet district, Mysore State, in 1954.

ACKNOWLEDGMENTS

We are thankful to Mr. B. Jobling of Wellcome Laboratories of Tropical Medicine, London and to Dr. F. Turk of Cornwall, England for their valuable suggestions.

Our thanks are also due to Prof. Theodor of Jeruslem (Palestine) for his kind help from time to time.

SUMMARY

1. This paper deals with the systematic study of Nycteribiids, Streblids, bugs, fleas and mites associated with bats in India.

2. In all 11 species of Nycteribiids viz. *Basilia scotti, Penicillidia bombayansis, P. fletcheri, P. enynsi var. indica, Nycteribia phillipsi, N. parvula, N. allotopa, Cyclopodia sykesii, C. ferrarii Tripselia amiculata* and *Eucampsipodia hyrtli orientalis* are recorded from Bombay State. Of these three are new to science. *B. bathybothyra* is not taken into consideration while describing the new species as it is not sufficiently known. The known species are redescribed with a complete set of figures pointing out the variations observed between the Indian and Foreign specimens. In addition the genitalia of all these forms has been described with suitable illustrations as they are of great taxonomic importance.

3. Of the 5 species of Streblids recorded from Bombay State, *Nycteribosca gigentea, N. amboinensis* and *N. modesta* are described along with genitalia for the first time.

4. *Bat-bugs : Cimex pipestrelli* and *Cacodmus indicus* are recorded and a few more additions to the existing figures have been made, filling the gaps in the original description.

5. Only *Thaumapsylla breviceps orientalis* a common flea on frugivorous bats of Bombay has also been recorded.

6. The family Spinturnicidae is discussed and a key to all the genera under the family is given for the first time. *Ancytropus indica, A. kanheri, A. zelebori, Meristaspis lateralis, Spinturnix psi, s. euryalis orientalis* and *Feriglischrus rhinolophi* are redescribed wherever necessary.

7. The family Macronyssidae is represented by *Steatonyssus hubli, Ichoronyssus lingarji* and *Hirstesia transvaalensis indica* from Bombay bats.

8. A record of *Neolaelaps magnistigmatus* belonging to the family Laelaptidae is made for the first time and it is a common mite on flying foxes in India.

9. Only three species of Myobid mites are so far known from Bombay bats. Of these *Foliomyobia barnleyi* is recorded without redescription, and *Foliomyobia jamesonia* and *Neomyobia tulsi* are new species.

10. Of the two species of Trombiculid mites reported here, *Whartonia brennani* and *Trambicula hampii* are new to science.

11. A note on bat fauna of Bombay State is given along with their geographical distribution.

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TEMPERATURE AND MOISTURE RELATIONS OF THE FUNGI CAUSING SEEDLING-ROT, ROOT-ROT AND WILT OF *CYAMOPSIS PSORALIOIDES DC*

I.—EFFECT OF TEMPERATURE ON THE GROWTH OF FUNGI IN ARTIFICIAL MEDIA

By BABU SINGH and R. S. SINGH, *Govt. Agricultural College, Kanpur.*

The soil conditions constitute the most important group of factors determining the prevalence of a soil-borne pathogen and the incidence of the diseases caused by it. Soil temperature is the most important single factor, which profoundly affects the incidence of root-rot and wilt diseases. The operation of this factor in determining the relative prevalence of soil-borne diseases has been largely dealt with in a monograph by Jones *et al.* (1). According to them, the variation in this factor may profoundly influence the occurrence or severity of diseases and may mask the influence of all other factors including severe infestation of the soil.

In the course of studies on the seedling-rot, root-rot, wilt and leaf-blight of clusterbeans (guar, *Cyamopsis psoralioides* DC), caused by *R. solani* and *F. coeruleum* (Lib.) Sacc., as, reported earlier (2,3), a number of laboratory and field experiments were carried out to assess the effect of temperature on the growth of the causal fungi and the incidence of mortality in *C. psoralioides*. The results of these investigations have been reported in the present and the subsequent papers.

MATERIAL AND METHODS

Single spore isolates of the two fungi were grown at different temperatures on solid and liquid media*. Two sets of quadruplicate plates containing solid media and three sets of triplicate flasks containing liquid media were kept at the adjusted temperatures in incubators. A similar number was kept at room-temperature (17°-22° C.) under bell jars covered with thick black paper to exclude light. The pH of the media was initially adjusted between 6.8 and 7.0. Linear growth of the fungi on solid media was determined by measuring the colony diameter daily (at intervals of 24 hours) till the surface of the medium in the plates was fully covered. The dry weight of the fungal mat in liquid media was determined on the 7th., 14th., and 21st. day after inoculation.

EXPERIMENTAL RESULTS

The results obtained during these experiments have been shown in tables I—IV. The data in tables I and II show that *R. solani* has given a better growth on two percent potato dextrose agar and Czapek's medium than on nitrate dextrose agar. Temperatures between 17°-22° and 32°C. appear to be favourable for the linear advance of the colonies which decreases at 35°C. The optimum temperature-range for linear growth of the fungus on solid media lies between 28°±0.5 and 30°±0.5. In liquid media also the fungus has grown best at 28°±30°C.

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*The media on which the fungi were grown were two percent potato dextrose agar, nitrate dextrose agar, Czapek's culture medium, Pfeffer's nutrient solution, Brown's standard agar, and Richard's solution.

From the data in tables III and IV it is seen that *F. coeruleum* isolated from wilted plants of *C. psoralioides* has grown well at all the temperatures from 17°C to 30°C. At 32°C. the growth of the fungus is scanty and proceeds very slowly after the 5th. day. No growth of the fungus has been obtained at 35°C. on any of the media tried. The optimum temperature-range for the fungus, as judged from the linear growth of the colonies and from the dry weight of the fungal mat, is 26°-28° C. though at 24°C. also the growth is almost equally good.

TABLE I.

Linear growth of *R. solani* on solid media at different temperatures.

Temperature	Media	Average colony diameter (millimeters) Days after inoculation					Average daily growth
(°C.)		1	2	3	4	5	(mm.)
17—22 (room)	2%potato dextrose agar	13	28	42	56	70	14
	nitrate dextrose agar	11	22	33	44	55	11
	Czapek's medium	13	27	40	52	65	13
24±1.0	2% potato	15	33	51	68	85	17
	dextrose agar nitrate	13	26	39	52	65	13
	dextrose agar Czapek's medium	13	28	44	60	75	15
26±0.5	2% potato dextrose agar	16	33	51	68	85	17
	nitrate dextrose agar	12	25	37	49	60	12
	Czapek's medium	14	29	43	57	70	14
28±0.5	2% potato dextrose agar	21	41	61	81	98	20
	nitrate dextrose agar	16	32	48	64	80	16
	Czapek's medium	20	40	60	81	98	20
30±0.5	2% potato dextrose agar	20	40	62	82	98	20
	nitrate dextrose agar	16	34	51	68	85	17
	Czapek's medium	20	41	63	84	98	21
32±1.0	2% potato dextrose agar	19	38	57	76	95	19
	nitrate dextrose agar	15	30	45	60	75	15
	Czapek's medium	18	36	54	72	90	18
±.0355	2% potato destrose agar.	10	21	33	44	55	11
	nitrate dextrose agar	8	16	24	32	40	8
	Czapek's medium	9	20	30	40	50	10

TABLE II.

Dry weight of the mycelial mat of *R. solani* in liquid media at different temperatures

Temperature (C°)	Dry weight of the fungal mat (gms.) on					
	Czapek's solution			Pfeffer's solution		
	Days after inoculation					
	7	14	21	7	14	21
17-22 (room).	0.214	0.600	0.688	0.395	0.687	0.711
24±1.0	0.294	0.689	0.761	0.411	0.739	0.786
26±0.5	0.317	0.704	0.780	0.493	0.761	0.789
28±0.5	0.430	0.792	0.896	0.617	0.942	0.116
30±0.5	0.451	0.863	0.903	0.654	0.943	1.120
32±1.0	0.407	0.730	0.776	0.519	0.866	0.902
35±0.5	0.204	0.469	0.531	0.318	0.621	0.649

TABLE III.

Linear growth of *F. coeruleum* on solid media at different temperatures

Temperature (°C)	Medium	Colony diameter (millimetres)						
		Days after inoculation						
		1	2	3	4	5	6	7
17-22 (room)	Brown's	4	11	18	24	30	36	42
	Richard's	6	12	18	25	31	37	43
	Czapek's	6	12	19	27	33	39	46
24±1.0	Brown's	8	20	32	43	54	65	76
	Richard's	9	20	33	45	57	69	79
	Czapek's	9	20	32	45	56	69	79
26±0.5	Brown's	10	22	34	45	56	68	80
	Richard's	10	23	35	47	59	71	83
	Czapek's	10	22	36	49	62	74	85
28±0.5	Brown's	13	25	37	49	61	72	82
	Richard's	13	26	39	52	64	76	87
	Czapek's	13	26	40	53	65	76	86
30±0.5	Brown's	2	9	16	22	28	33	38
	Richard's	4	12	20	26	32	38	43
	Czapek's	5	12	20	27	34	39	45
32±1.0	Brown's	0	0	2	4	5	6	6
	Richard's	0	0	3	5	7	8	8
	Czapek's	0	0	3	6	8	9	10
35±0.5	No growth on any media at this temperature							

TABLE IV.

Dry weight of the mycelial mat of *F. coeruleum* in liquid media at different temperatures

Temperature (°C)	MEDIUM	Dry weight of the mat (gms.) Age of the culture (weeks) 1	2	3
17-22 (room)	Brown's	0.102	0.129	0.194
	Richard's	0.173	0.204	0.270
	Czapek's	0.169	0.203	0.241
24±1.0	Brown's	0.196	0.258	0.430
	Richard's	0.246	0.287	0.496
	Czapek's	0.257	0.298	0.506
26±0.5	Brown's	0.206	0.331	0.406
	Richard's	0.269	0.384	0.499
	Czapek's	0.299	0.431	0.513
28±0.5	Brown's	0.269	0.334	0.446
	Richard's	0.310	0.390	0.501
	Czapek's	0.309	0.433	0.520
30±0.5	Brown's	0.104	0.189	0.197
	Richard's	0.146	0.190	0.206
	Czapek's	0.161	0.198	0.212
32±1.0	Brown's	0.014	0.017	0.018
	Richard's	0.019	0.021	0.022
	Czapek's	0.018	0.023	0.025
35±0.5	No growth on any media at this temperature.			

SUMMARY

During the course of studies on the seedling root-rot, wilt and leaf-blight of cluster-beans (guar, *Cyamopsis psoralioides* DC), caused by *Rhizoctonia solani* Kuhn. and *Fusarium coeruleum* (Lib). Sacc., it has been found that in artificial media *R. solani* grows best at 28°-30° C. and *F. coeruleum* at 26°-28° C.

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PLATE I

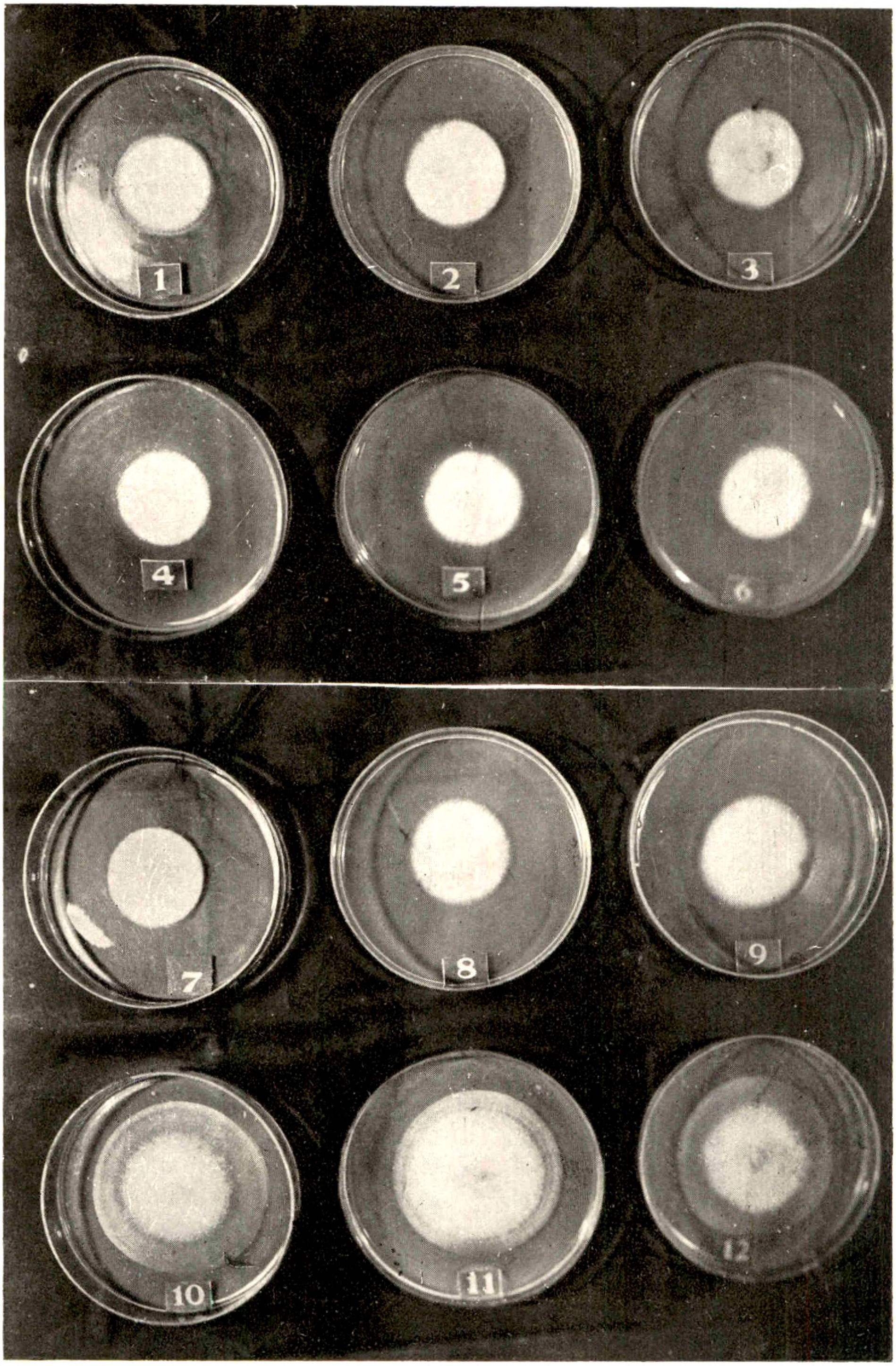
BABU SINGH and R. S. SINGH : On Fungi attacking cyamopsis

Figs. 1-3. One week old growth of *F. coeruleum* on Brown's standard Agar at room temperature (17° -22° C.)

Figs. 4-6. One week old growth of *F. coeruleum* on Richard's medium at room temperature (17° -22° C.)

Figs. 7-9. One week old growth of *F. coeruleum* on Czapek's medium at room temperature (17° -22° C.)

Figs. 10-12. Two-week's old growth of *F. coeruleum* at 30°C. on Czapek's medium (10), Richard's medium (11) and Brown's standard agar (12).



Babu Singh and R. S. Singh

PLATE II

BABU SINGH and R. S. SINGH : On Fungi attacking cyamopsis

Fig. 16. One week old growth of *F. coeruleum* at 24° C. on Richard's medium
Fig. 17. One week old growth of *F. coeruleum* at 24° C. on Brown's agar
Fig. 24. One week old growth of *F. coeruleum* at 24° C. on Czapek's medium
Fig. 13. One week old growth of *F. coeruleum* at 26° C. on Richard's medium
Fig. 15. One week old growth of *F. coeruleum* at 26° C. on Czapek's medium
Fig. 25. One week old growth of *F. coeruleum* at 26° C. on Brown's agar.
Fig. 20. One week old growth of *F. coeruleum at* 28° C. on Richard's medium
Fig. 21. One week old growth of *F. coeruleum* at 28° C. on Brown's agar.
Fig. 22. One week old growth of *F. coeruleum* at 28° C. on Czapek's medium
Fig. 27. Eighteen day old growth of *F. coeruleum* at 32° C. on Richard's medium
Fig. 28. Eighteen day old growth of *F. coeruleum* at 32° C. on Brown's agar.
Fig. 29. Eighteen day old growth of *F. coeruleum* at 32° C. on Czapek's medium.

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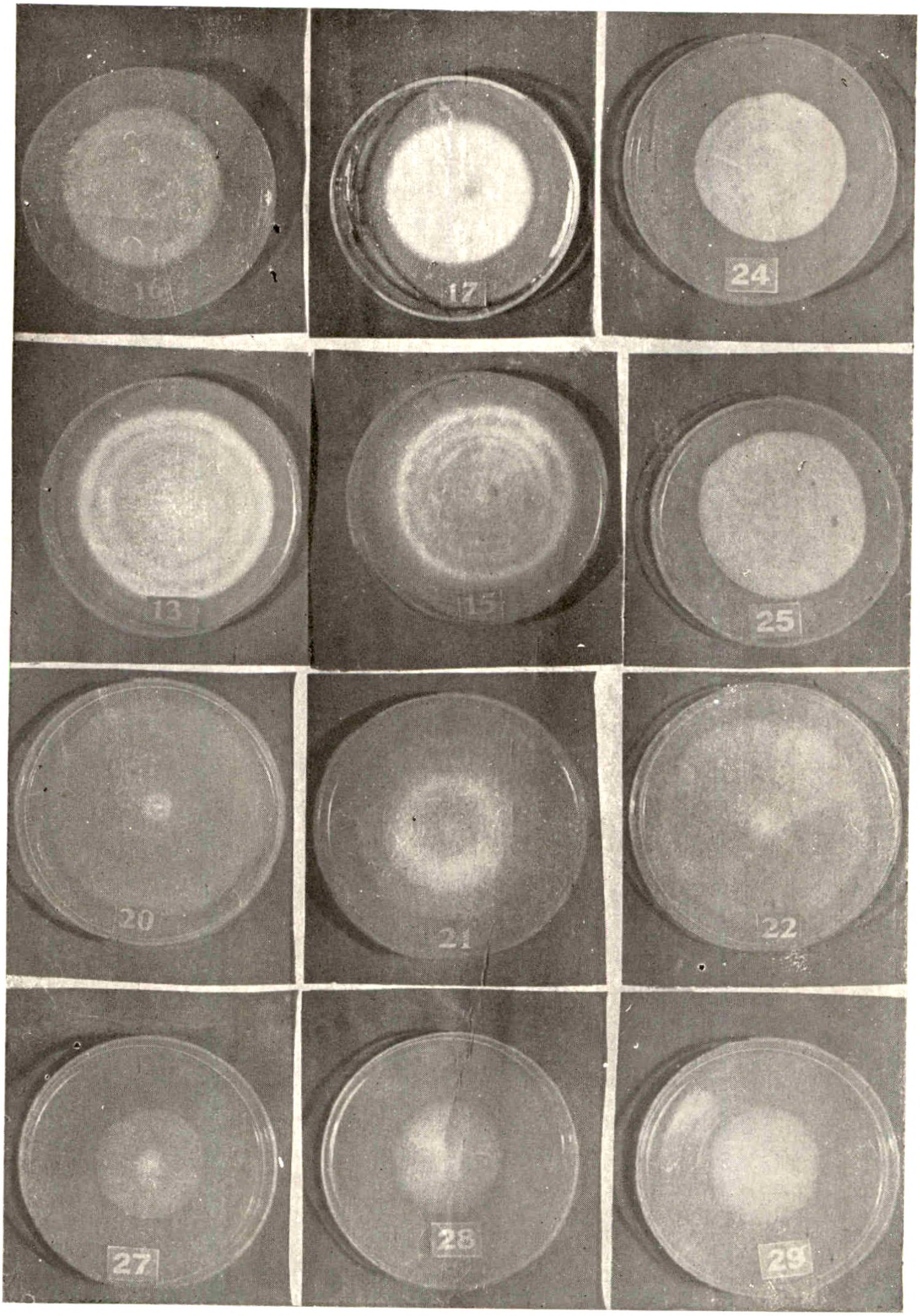

Babu Singh and R. S. Singh

TEMPERATURE AND MOISTURE RELATIONS OF HE FUNGI CAUSING ROOT-ROT, SEEDLING-ROT, WILT AND LEAF-BLIGHT OF *CYAMOPSIS PSORALIOIDES*

II.—Effect of Soil-moisture on Mortality under Contrclled Ccnditions

By Babu Singh and R. S. Singh, *Govt. Agricultural College, Kanpur.*

In the case of root-rot and wilt diseases temperature and moisture have a profound influence on the virulence of parasite and severity of disease (3). The majority of the wilt diseases are known to be favoured by a high soil-moisture content. Mortality due to wilt diseases, caused by *Fusarium* spp., becomes, for example, most common soon after irrigation in clear weather. According to Clayton (1) tomato plants are almost immune to infection by *F. lycopersici* at saturation or at 13-19 percent soil-moisture, the optimum for disease development being 45 to 95 percent. Fikry (3) found optimum moisture for cotton wilt (*Fusarium* spp.) to be 60 percent at 21°-24° C. and 50 to 70 percent at 27°-30° C. This is an indication that at high soil-temperature a high soil-moisture is more inductive to the disease. *Fusarium vasinfectum* (causing cotton wilt) was found by Tharp and Young (7) to produce maximum disease at a moisture content of 80-90 percent saturation, while in India Kulkarni (5) reported no significant correlation of cotton wilt incidence with soil-moisture. Uppal and Kulkarni (8) found that *F. vasinfectum,* causing wilt of sannhemp, is most destructive at 26°-28° C. in soils with low moisture content (15%) and the disease incidence falls down at 20 percent soil-moisture. Linford (6) reported that soil-moisture has less influence than temperature upon pea wilt (*F. orthoceras var. pisi*). Wet soil slightly favours early developement of symptoms, but drier soils favour more rapid death of affected plants. On the other hand Walker and Synder (9) report that the wilt of peas is favoured by high soil-moisture. Johnson (4) states that fusarium wilt of tobacco (*F. oxysporum* var. *nicotianae*) occurs equally well both in wet as well as relatively drier soils. However, relatively dry soils give good artificial infection.

Material and Methods

The present paper deals with the studies upon the relation of soil-moisture to the incidence of mortality in *Cyamopsis psoralioides* DC caused by *Rhizoctonia solani* Kuhn and *Fusarium coeruleum* (Lib.) Sacc. through seedling-rot, root-rot, wilt, and leaf-blight. The adjustment of the soil-moisture in pots was made according to the method followed by Dickson (2). The moisture content of the soil was kept as nearly constant during the period of experiment as possible by weighing the pots daily and adding water to restore the original weight. A mulch of coarse sand was laid on the soil surface to minimize the loss of moisture through evaporation.

There were four series each with eight sets of pots for the different soil-moisture adjustments. Emergence was studied in a separate series (Table 1). In each case the inoculation of the soil with pure cultures of the fungi was done a fortnight before sowing. The soil-temperature in the pots during the period of experiment varied between 25° and 31° C. Disease-incidence was recorded regularly for six weeks after emergence (Table 2).

EXPERIMENTAL RESULTS

The emergence (Table I) has been perfect in all the soil-moistures in the uninoculated series. *R. solani* has inhibited the emergence of seedlings almost equally in pots adjusted at 15 to 60 percent soil-moisture. In the lowest percentage of soil-moisture the seeds are found enveloped in a cottony mass of hyphae while in higher soil-moisture there is rapid rotting of the seeds and unemerged seedlings. *F. coeruleum* shows a tendency to check the emergence in the low soil-moisture where usually the ungerminated or partially germinated seeds are found rotting. In higher soil moisture the emergence of seedlings is perfect. In soil inoculated with both the fungi together the emergence is low in all the soil-moistures tried. In this series there are indications that the emergence increases after 40 percent soil-moisture. This is apparently due to the effect of moisture on the relative growth of the fungi.

Mortality due to *R. solani* has been high even at 15 percent moisture. It goes on increasing and reaches the highest figure when the moisture in the soil is 40 percent of the moisture-holding capacity. In higher levels of moisture the effects of the fungus are reduced. The types of symptoms produced have been variable according to the amount of moisture present in the soil. Upto 20 percent soil moisture the fungus has usually produced localised necrosis of the hypocotyle and sometimes of the root, while in higher moisture contents there has been systematic rotting of the root and sometimes of the entire seedling.

F. coeruleum causes higher mortality of plants than *R. solani* at 15 percent soil moisture. Its activity increases with the soil moisture upto 30 percent but after that it falls down gradually and at 50-60 percent moisture the mortality is lower than at 15 percent. This suggests that wilt caused by *F. coeruleum* is favoured by low moisture contents of the soil than by high soil moisture.

TABLE I

Effect of soil-moisture on emergence of seedlings of *Cyamopsis psoralioides* in soil inoculated with *R. solani* and *F. coeruleum* individually and combined together.

Treatments (series)	PERCENTAGE* OF EMERGENCE Soil moisture (percent)							
	15	20	25	30	35	40	50	60
Uninoculated (check)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Inoculated with *R. solani*	68.3	70.0	70.0	68.3	70.0	68.3	66.7	68.3
Inoculated with *F. coeruleum*	96.7	96.7	98.0	100.0	100.0	100.0	100.0	100.0
Inoculated with *R. solani* and *F. coeruleum*	50.0	53.3	53.3	50.0	50.0	53.3	56.7	58.3

*Based on 30 seeds sown.

TABLE II

Effect of soil-moisture on the incidence of mortality in *Cyamopsis psoralioides* caused by *R. solani* and *F. coeruleum* individually and combined together.

Treatments (Series)	PERCENTAGE OF MORTALITY (in six weeks) Soil-moisture (percent)							
	15	20	25	30	35	40	50	60
Uninoculated (Check)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inoculated with *R. solani*	43.3	60.0	73.3	83.3	86.7	93.3	90.0	86.7
Inoculated with *F. coeruleum*	46.7	50.0	63.8	66.7	53.3	53.3	33.3	20.8
Inoculated with *R. solani* and *F. coeruleum*	93.3	96.7	100.0	100.0	93.3	93.3	90.0	88.3

SUMMARY

During a study on the effects of soil-moisture on mortality in *Cyamopsis psoralioides* DC, caused by *Rhizoctonia solani* Kuhn and *Fusarium coeruleum* (Lib.) Sacc., it has been found that pre- and post-emergence losses due to *R. solani* are very high at 15 to 60 percent soil moisture, the optimum moisture for disease development being above 30 percent. *F. coeruleum* produces some inhibitory effect on the emergence only in low soil-moisture. The figures for mortality caused by this fungus are highest at 25 to 30 percent soil-moisture. Combined together, the two fungi are almost equally severe at 15-60 soil-moisture. There is evidence that upto 20 percent soil-moisture *R. solani* produces localised necrosis of the hypocotyl and roots while in higher soil-moisture there is systematic rooting of the root or the entire seedling.

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EFFECT OF SODIUM SULPHATE ON EARLY SEEDLING GROWTH OF GRAM AND WHEAT

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INTRODUCTION

Soil salinity and alkalinity are problems of great importance to the agriculturist. Even in irrigated areas in semi-arid regions, large tracts are rendered uncultivable due to high salinity or alkalinity in the surface soil. Germination and seedling growth of crop plants are adversely affected.

Soil salinity is attributed to a high concentration of total soluble salts in the soil, particularly of sodium, and are known to lead gradually to alkaline conditions. Desai and Sen (1) have reported for soils from Pusa, Bihar, 0.269% of sodium sulphate (on oven-dry weight of the soil) from alkaline patches (depth 0-6") and 0.026% from normal areas (depth 0-20"). From Karnal area Sen (12) estimated 0.118% and 0.212% of sulphate of sodium from alkaline (depth 0-7") and saline (depth 0-5") areas respectively. In Jamuna-Khadar area Raychaudhary and Tripathi (11) have reported 0.073% and 0.032% of sulphate at 0-7" and 0-11" depth in saline soils, respectively. Thus the concentration of sodium sulphate in the surface soil in the gangetic alluvium may range from 0.026% in normal soil to as high as 0.269 (on oven dry soil) in alkaline or saline areas. Reclamation of such areas is attempted both by soil-amelioration methods and by growing suitable salt or alkali-tolerant crops with varying success. Detailed physiological studies relating to the effect of sodium sulphate on germination, growth and maturity of different crops have not been attempted in India in a systematic manner so far, although during the last two decades much work has been carried out outside India on plant growth as influenced by specific sodium salts in different concentrations. Lyon (9) reported that the height of tomato plants, dry weight of root system, dry weight of vines, total fresh weight of immature fruits and the number of immature fruits decreased with every increase of 40 m. e. of sodium sulphate. Hayward and Long (5) studied the effect of sodium sulphate in concentrations varying from 1, 5 to 6 atmospheres on tomato plants and found that the growth of the plants as measured by weight and diameter of stem and dry weight was less at the high concentrations than at the control or 1.5 atms. level. Again in 1943, the same authors observed reduction in height and diameter of stem in tomatoes with every increase of 40 m.e. in sulphate series. Eaton (2) found a greater root growth of corn and tomato in solutions of low concentrations than in those of high. Magistad *et al.* (10) investigated the influence of Sulphate concentrations ranging from 0.4 to 4.4 atms. on growth of beets, carrots, and beans and observed reduction in growth and yield in these concentrations. Hayward and Long (5) observed that high concentrations of sulphate salts resulted in marked reduction of linear growth and weight and volume of Elberta peach trees. In 1946 they again reported that increases in concentration of nutrient solution due to addition of sulphate salts (65% Na) resulted in decreased vegetative growth of Elberta peach trees.

However the experimental evidence concerning the early seedling growth of crop plants such as gram and wheat as influenced by a single salt like sulphate of sodium is lacking.

In the present study an attempt is made to find out the influence of varying concentrations of sodium sulphate, ranging from 0.2% to 0.8%, on early seedling growth of gram, a 'salt-susceptible' crop and wheat, a relatively tolerant crop.

MATERIAL AND METHODS

Early seedling growth of gram N. P. 58 and wheat C. 591 was studied as influenced by different concentrations of sodium sulphate solution (0.2%, 0.4%, 0.6% and 0.8%). The technique adopted was essentially that of Garrard (4). Test tubes of uniform size were fitted with rolls of filter paper folded at the top into a cone to support the seeds. The tubes were filled with sodium sulphate solutions upto one-third level so that the solution might not come in direct contact with the growing root, the salt solution being supplied to the root through capillary action of the filter paper. Two seeds per tube were transferred to the edge of the filter paper cone and the radicles were allowed to grow between the paper roll and the glass wall of the tube. The tubes were kept at a temperature of about 30°C. in a humid dark chamber.

Five series consisting of the four salt concentrations and one control (distilled water) with twelve replications were maintained and daily observations upto 96 hours after sowing were recorded for the total length of the roots and of the plumule. The results were analysed statistically on factorial basis as shown below :

	D. F.
Due to 'Salt-levels':	4
,, ,, 'Age' :	2
Salt-levels x Age:	8
Residual	165
Total	179

It may be noted that the seeds began sprouting 24 hours after sowing and thus the root-length could be measured daily from 48 hours after sowing upto the end of 96 hours. Regarding plumule growth, only one observation at the end of 96 hours was possible for gram and two (after 72 and 96 hours) for wheat. The statistical calculations for these observations are suitably altered, *i.e.*, in gram, the factor 'age' is absent and in wheat, the d. f. due to 'age' is one, and due to interaction : 4, and residual : 170.

RESULTS

Gram : Root-growth :

The results are given in Table I which shows the effects of the main factors ('age' and 'salt-levels') as well as that of their interaction. The values for the respective Critical differences are also included.

TABLE I. Effect of a supply of different concentrations of Na_2SO_4 sloution on root-growth (in mms.) in gram seedling. (Mean of 12 values).

'Age' (Hours after sowing)	'Salt-levels'					'Age' (Mean of 60 values)	*C. D. for 'Age'
	0 (Control)	0.2%	0.4%	0.6%	0.8%		
Hours							
48	34.31	34.90	29.90	25.59	19.95	28.93	
72	68.63	55.45	44.50	38.63	29.68	47.38	2.94
96	104.27	67.00	51.59	43.90	35.09	60.37	
Mean of 30 values	69.07	52.45	42.00	36.04	28.04		
C. D. for 'Salt-levels'			3.80				
C. D. for 'interaction'			6.58				

*The values of Critical differences (C.D.) in the present studies relate to 5% level.

Age: It is clear that the root-length increased with the age of the seedling, irrespective of the salt-treatment. During the first 24 hours after sowing, the seeds were absorbing water and swelling up and many of them started sprouting. Elongation of the radicle began after this period. Growth of the root during the following day was about 29mm. and later on it slowed up ; during the fourth day after sowing, it was only about 13mm.

Salt-levels: Irrespective of the age of the seedling, there was a graded adverse affect on root-growth witn increase inconcentration of the sodium sulphate solution ; the differences due to the successive increments in concentration of the solution ranged up as: 16.6mm., (0 to 0.2% Na_2so_4 solution), 10.4mm. (0.2% to 0.4%), 5.96mm. (0.4% to 0.6%) and 7.80mm. (0.6% to 0.8%).
Interaction: 'Age' x Salt-levels' :

The above results for the two main factors do not give a complete picture, as the interaction has also become significant at 5% level. Initially , *i.e.*, by the end of 48 hours, a significant difference in the root-length was noted only with a difference of 0.4% in the concentration, when the effects of the sulphate concentrations were compared among themselves. Further there was no significant difference in the root-length between the 'Control' (root-length 34.31mm.)

and even 0.4% Na_2SO_4 solution (29.90mm.). At the end of three days, the root-growth in 0.4% and 0.6% solution was almost the same, the mean values being 44.50mm. and 38.63mm. respectively and the 'Critical difference' 6.58. Root-growth of four-day old seedling was significantly lowered with each successive increase in the Sulphate concentration. Again root-growth in 3-day old 'control' seedling (68.63mm.) was as good as that (67.00mm.) of 4-day old seedling in 0.2% solution. Similarly each successive increase in the sulphate concentration retarded the root-elongation to an extent that at the end of 4 days, the root-length in any particular concentration was nearly equal to the root-length of 3 day-old seedling in the previous lower concentration as shown below :—

	Control	0.2%	0.4%	0.6%	0.8%	C. D.
72 hours	68.63	55.45	44.50	38.63	—	6.58
96 hours	—	67.00	51.49	43.90	35.09	

Moreover, in the two higher concentrations, 0.6% and 0.8% the root-elongation gradually slowed up, so that the increase in length during the last day was not significant.

Plumule growth: The Plumule appeared after 72 hours and its length was measured after 96 hours, at the end of the experimental duration. The results are given below :

TABLE II. Effect of a supply of different concentrations of Na_2SO_4 sloution on plumule growth (in mm.) in gram seedling. (Mean of 12 values)

Hours after sowing	Salt-levels					C. D.
	0 Control	0.2%	0.4%	0.6%	0.8%	
96 hours	25.45	17.09	15.22	12.40	12.36	2.24

The difference in plumule length between 0.2% solution (17.09) mm. and 0.4% solution (15.22 mm.) was not significant ; similarly between 0.6% and 0.8% solutions (plumule length; 12.40 mm. and 12.36 mm.). The control plants receiving pure water showed the best plumule growth (25.45 mm.).

Wheat: Root-growth :

The results summarised below indicate that the main factors, 'age' and 'salt-level' were significant while their interaction was not so.

TABLE III Effect of a supply of different concentrations of Na_2So_4 solution on root-growth (in mms.) in wheat seedling. (Mean of 12 values).

'Age' (Hours after sowing)	'Salt-levels'					'Age' (Mean of 60 values)	C. D. for 'Age'
	0 (Control)	02%	04%	06%	08%		
48	42.6	35.5	26.4	20.4	16·7	23.2	
72	138.2	118.8	90.2	84.1	73·9	101.2	9.1
96	200.0	179.4	147.5	139.7	124·0	58.3	
Mean of 36 values	126.9	112.2	87.9	81.7	71.8	71·8	
C. D. for 'Salt-levels'			11.8				

Note :—Interaction 'age' x 'salt-levels' is not significant.

'Age' : Irrespective of the salt-levels the mean total root-length increased considerably with the age of the seedling, the increase being greater during the third day (73 mms.) than in the following day (57.1 mm.).

'Salt-levels' : Irrespective of the age of the seedling, mean total root-length of the 'control' plants (126.9 mm.) was significantly greater than in the plants receiving salt solutions. The root-length decreased with increase in the concentration of the sulphate solution although there was no significant difference in the root lengths with 0.4% and 0.6% solutions, the root-length being 87.9 mm. and 81.7 mm. respectively; similar was the case between 0.6% and 0.8% solutions, wherein the root-lengths were 81.7 mm. and 71.8 mm.

The lack of significance for the interaction between 'age' and 'salt-levels' indicated that each factor shows the same effect at any level of the other factor. The trend of the effects of each factor is specific and is not altered to any extent by the presence of the other factor.

Plumule growth : Unlike gram, plumule of wheat plants started growing from 48 hours after sowing, thus facilitating growth observations at the end of the third and fourth days. The mean values along with the respective critical differences for 'significant' factors are included in Table IV.

TABLE IV. Effect of a supply of different concentrations of Na_2SO_4 on plumule growth (in mms.) in wheat seedling. (Mean of 12 values).

'Age'	'Salt-levels'					'Age'	C. D. for
(Hours after sowing)	0 (Control)	0.2%	0.4%	0.6%	0.8%	(Mean of 60 values)	'age'
Hours							
72	23.3	21.0	16.0	13.2	11.2	16.9	
96	43.7	41.9	37.8	33.1	26.7	36.7	2.0
Mean of 24 values	33.5	31.4	26.9	23.2	19.0		
C. D. for 'Salt-levels'			9.1				

Note : Interaction, 'age' x 'Salt-levels' is not significant.

'Age' : The plumule growth started slowly in the beginning (mean length for all the 'salt-levels' being 16.9 mm. during the third day) and on the following day it increased by 19.8 mm.

'Salt-levels' : Irrespective of the age of the seedling, the plumule-length showed a tendency to decrease with increase in concentration of salt solution. However, a significant difference in plumule-length was observed only with a difference in concentration of 0.6%. Thus there was apparently no difference in plumule-length between 'Control' and 0.4% sulphate solution and similarly between 0.4% and 0.8% solution.

The interaction was not significant.

DISCUSSION

Comparison between gram and wheat

As the two crop plants are quite different from one another, one with tap-root system and the other with fibrous type, a comparison of the effect of the sulphate concentrations on root and plumule growth could be made on a relative basis relative to the respective controls. Even by the end of 96 hours after sowing, lateral roots did not appear in gram, while in wheat adventitious roots appeared much earlier. Thus in gram, the root-length relates to main root (radicle), while in wheat, it is the total length of all the roots.

Root-growth (Figures 1 & 2) : It was in general better in wheat than in gram; so also was the rate of root growth. Although root-elongation in gram and

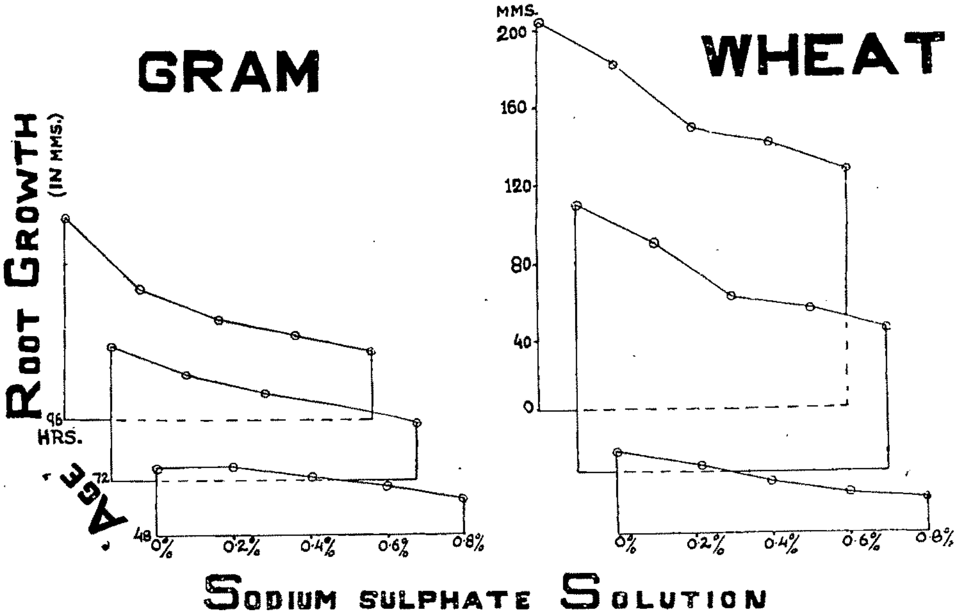

Fig. 1. Effect of supplying different concentrations of sodium sulphate solution on root-growth in seedlings of gram and wheat, at the end of 48, 72 and 96 hours ('age') after sowing.

wheat was similarly affected by the different concentrations of the sulphate solution, the intersity of the effect was less for wheat as shown below :—

Percentage root-length on respective controls at the end of 96 hours

	Concentration of sulphate solution			
	0.2%	0.4%	0.6%	0.8%
	%	%	%	%
Gram	64.3	49.5	42.1	33.7
Wheat	89.7	73.8	69.9	62.0

It is clear from the above figures that gram is relatively more susceptible to sodium sulphate than wheat. The root-length of 4 days old gram seedling in 0.8% sodium sulphate solution was only one-third of the root-length of plants without a supply of the salt (control) ; in wheat, it was 62% of the control.

The daily rates of the root-growth in gram and wheat in the different treatments expressed as percentage rates for control are :

Relative daily growth rates of gram and wheat (% on respective growth rate of control)

	Gram				*Wheat*			
After sowing	0.2%	0.4%	0.6%	0.8%	0.2%	0.4%	0.6%	0.8%
	%	%	%	%	%	%	%	%
24-48 hrs.	102	88	75	59	83	61	48	39
48-72 „	60	43	38	28	87	67	67	60
72-96 „	32	20	15	15	98	93	90	87

The above figures are revealing regarding the differential behaviour of gram and wheat. The rate of root-growth in gram for the second day after sowing was relatively less adversely affected by the sulphate supply than in wheat. However, gradually the rate of root-growth in wheat, even with the sulphate supply, improved considerably, while that of gram went down.

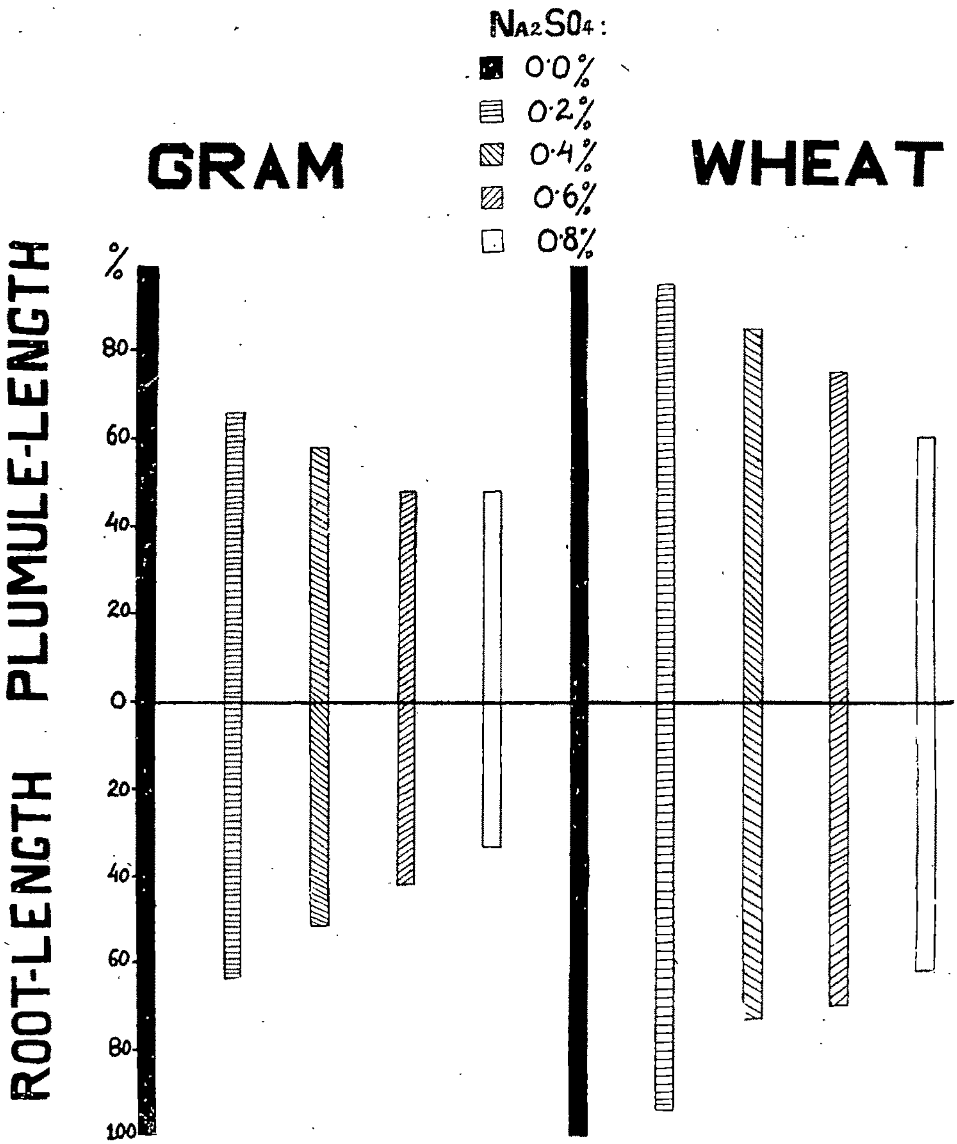

Fig. 2. Effect of supplying different concentrations of sodium sulphate solution on growth of roots and plumule of seedlings of gram and wheat, 96 hours after sowing (Exprcssed as percentages on respective controls—0.0% Na_2SO_4)

Plumule growth (Fig. 2.) : The plumule lengths of gram and wheat at the end of 96 hours, are given below for the different concentrations of sulphate as percentages on the respective controls.

	Plumule length (% on control)			
	0.2%	*0.4%*	*0.6%*	*0.8%*
Grem	67	59	49	49
Wheat	96	86	76	61

Even regarding plumule growth, the sulphate-effect was more pronounced with gram than with wheat.

As already pointed out, literature relating to the effect of sodium sulphate on early seedling growth is scanty. The researches related mostly to full grown plants. Growth in tomatoes, corn etc. decreased with increase in concentration of sodium sulphate (2,5). The present data on root and plumule growth of young seedling of gram and wheat also support the above conclusions regarding the influence of a supply of increasing concentrations of sodium sulphate solution. The differential response of crop plants to a supply of sodium sulphate was recognised by Eaton (2) who pointed out that beet and tomatoes are more tolerant to sulphate than beans. In the present study, gram was found to be relatively more susceptible to the salt than wheat. Further, the adverse effect on root-growth observed in wheat on the second day after sowing, tended to decrease in the following days ; on the other hand, gram was relatively more tolerant on the second day after sowing but its rate of root-growth fell away in the following two days.

It has been pointed out elsewhere that the surface soil in saline and alkaline areas of the Gangetic alluvium may contain as high a concentration of sodium sulphate as 0.212% (12), and 0.026% (1) (for normal fields) on oven-dry soil. It would be interesting to know the concentration of the sulphate in soil solution of loam soil at 'field capacity' with 20% as available soil moisture (assuming thgt the water-holding capacity of the alluvial loam soil to be about 25% and wilting coefficient as 5% and also assuming that all the sodium sulphate is in solution). The values along with thereby other workers would be :

		Soil %	*According to*	Concentration of Na_2So_4 in *Soil Solution (Calculated)* %
Saline :				
Karnal (Punjab)	(*i*)	0.212	Sen, 1953	1.060
Jamuna Khadar area	(*ii*)	0.073	Raychaudhary and Tripathi 1953	0.365
,,	(*iii*)	0.032		0.160
Alkaline :				
Pusa (Bihar)	(*i*)	0.269	Desai and sen, 1953	1.345
Karnal (Punjab)	(*ii*)	0.118	Sen, 1953	0.590
Normal :				
Pusa (Bihar)		0.026	Desai and Sen, 1953	0.130

Except the extreme values of 1.06% and 1.345% of the sulphate in the soil solution, the others range from 0.160% to 0.365% for saline or alkaline soils while it is 0.130% for the normal soil. In the present studies, the percentage concentration varied from 0.2% to 0.8%. Even with the lowest concentration (0.2%) the cumulative effect of continous supply of Na_2So_4 for 4 days resulted in a reduction in root growth by 35.7% in gram and only 10.3% in wheat, compared to the respective controls ; in 0.4% concentration, however, the respective reduction was 50.5% and 26.2% Thus even a low concentration of sodium sulphate in soil, when present for a long duration, may effect plant growth considerably (to different degrees in different plants) even when the soil moisture is fairly high. With lower levels of soil moisture, normally met with even in irrigated fields, the adverse effect will be more intensified. In the above discussion, however, it should be remembered that the present data relate to the supply of a solution containing sodium sulphate alone while the soil solution contains many other solutes. Its implication can not be neglected and require further clarification.

SUMMARY AND CONCLUSIONS

Following the technique of Garrard (4) for studying root-growth in early seedling stage, seeds of gram N. P. 58 (*Cicer arietimum*) and wheat C. 591 were sown at the top of filter-paper rolls fitted into test tubes (filled up to one-third with water or solution), so that the roots could grow vertically downward between the filter-paper and the glass-side. The effect of 0.0%: 0.2%, 0.4%, 0.6% and 0.8% of Na_2So_4 solutions on root-and plumule-growth was studied daily up to 96 hours after sowing. Twelve replications were maintained and the results wereanalysed statistically.

Total root-length of wheat was generally greater than that of gram. By the end of 4 days, the root-growth of gram was significantly lowered with each successive increase in the concentration of the sulphate. In wheat the root-growth was significantly lower even with 0.2% than with water alone ; but there was no significant difference in root-growth between 0.4% and 0.6% or between 0.6% and 0.8% solutions. With 0.8% solution, root length of gram was only 33.7 % and of wheat 89.7%, compared to their controls ; with 0.2% solution, the respective root-growths of gram and wheat were 64.3% and 89.7%

Intially, up to 48 hours after sowing, root-growth in gram was more adversely affected by the salt solution than in wheat ; the latter improved gradually while gram suffered more and more with continuous supply of the salt solution.

Plumule growth was also affected similarly by the sulphate solution, gram suffering more than wheat.

ACKNOWLEDGMENTS

We are thankful to Dr. S. Sinha, Head of the Department of Botany, Agra, College, Agra, for facilities and are also grateful to the U. P. Research Grants Committee for the endowment of a grant for studying salt-tolerance in crop plants.

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FLORAL ANATOMY OF *CANNABIS SATIVA* L.

By S. P. Singh, *Department of Botany, B. R. College, Agra (India).*

Bechtel (1) described the floral anatomy of *Cannabis sativa* along with a number of other members of the order Urticales. According to him the pedicel of the female flower has four vascular bundles, one of which passes off anteriorly into the bract. The bundle lying opposite the bract-supply ascends up and ends into the solitary pendulous ovule.

The remaining two vascular bundles pass up as the dorsal carpellary bundles of the two carpels and end at the tip of the style. His remarks about the perianth supply are, however, most significant. A transverse section of the flower just below the ovule shows six distinctly lignified bundles in the perianth. The appearance of the tissue of the perianth suggests more bundles than those having vessels. None of the bundles, even those with lignified cells, in the upper position, can be followed to their origin in the floral axis. The posterior bundle can be followed down the farthest, that is into the cortex of the pedicel or the receptacle. It appears that the perianth bundles are abortive in the lowest part of their course. From his description it is clear that he could not find the connections of the perianth traces with the main ring of the floral axis. A similar occurence of the abortive bundles without their connections with the main ring is described in a number of Santalaceous genera by Rao (3) and Smith & Smith (6). Paliwal (2) has recently shown that these bundles remain for a long period in a procambial condition and their differentiation takes place basipetally, on account of which the earlier workers failed to recognize their presence in the basal region. Similarly the observation of Bechtel (1) that the perianth traces have no connections with the main ring in *C. sativa* might also be due to the basipetal differentiation of the bundles and the persistence of the procambial nature of the bundles for a longer period. Possibly the author did not study the structure in the older flower, where the differentiation has reached up to the stele of the pedicel. The bundles possibly also retain procambial condition throughout their life. He has mentioned further the presence of the tissue suggesting vascular bundles in the stele of the pedicel. The connections of these were not clear, but he considered them as the abortive bundles which might have passed out and entered the perianth. He has also reported the occurence of faint vascular tissue in the lateral part of the ovary wall, suggestive of the carpellary bundles either as branches of the dorsal carpellary bundles or abortive bundles of the carpels which have been lost. Here again he has not been able to trace the connections of these bundles. The observations of Bechtel (1) stated above are subject to grave doubts, and, therefore, a reinvestigation of the floral anatomy of *Cannabis sativa* L. is undertaken to verify them.

MATERIAL AND METHOD

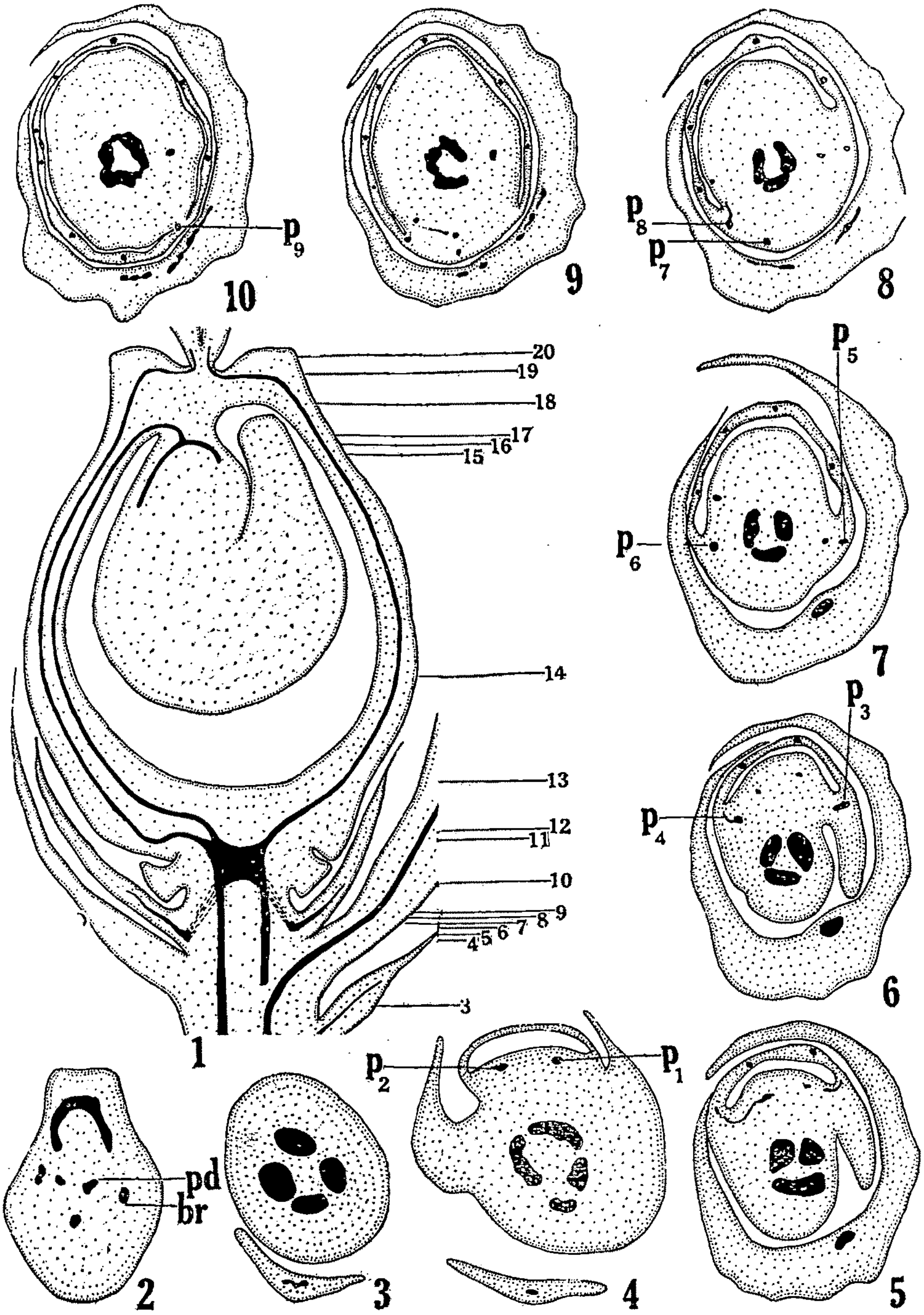
Flowers and fruits of different stages of *Cannabis sativa* L. were collected from the Botanical Garden, B. R. College, Agra, fixed in formalin-acetic-alcohol series and embedded in paraffin. Sections ranging from 8μ to 12μ in thickness were cut and were stained with safranin-fast green and crystal violet-erythrosin combination, the latter proved better than the former.

VASCULAR SUPPLY OF THE FEMALE FLOWER

Fig. 1 represents diagrammatically the longitudinal course of the vascular supply of the female flower of *C. sativa*. Horizontal lines marked with index numbers denote the level at which transverse sections have been taken. The numbers denoting the horizontal lines are the same as marked for the transverse sections except Fig. 2.

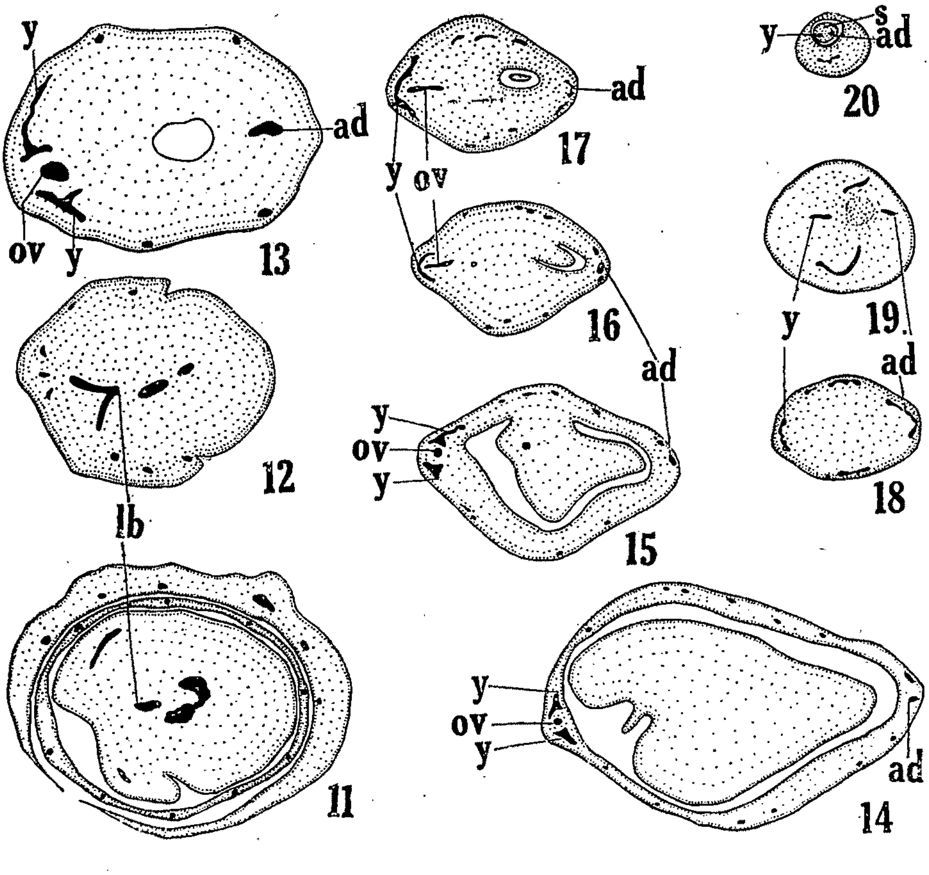
The vascular supply to the bract arises from the stele of an inflorescence axis first of all (Fig. 2, br.). After the supply to the bract is over, the vascular strands, entering the pedicel of each flower, are organized into four bundles (Figs.2, pd & 3). One of these four bundles moves apart and finally passes out as a trace to the bracteole where it divides into a number of branches leaving only three bundles in the pedicel of the flower. Transverse section at the level 4 shows towards the posterior side two bundles in the peripheral region of the receptacle (Fig. 4; pl, p2). A trace from each of these is seen to enter the perianth segment of that side at the level 5, but before this has happened the trace to the bracteole has already entered that organ (Fig. 5). Transverse sections at the levels 6-10 (Figs. 6-10) show about 6-7 bundles more making their appearance in the anterio-lateral side in the sequence of p3, p4, p5, p6, p7, p8 & p9. If imaginary line is drawn connecting all these in a serial order, a zig-zag path is formed (Figs. 6-10). From each of these bundles also a trace is given out to the gamophyllous perianth. In transverse sections the connections of these receptacular bundles with the main stele could not be made out easily but in longitudinal sections of comparatively older flowers, they were clearly seen in procambial condition.

After cutting the perianth supply, the three vascular bundles of the main stele organize into a more or less complete cylinder (Fig. 10). At the levels 11 & 12 a vascular trace from the main stele passes out obliquely in a slightly downward direction, and bifurcates ultimately (Figs. 11 & 12, lb). Each branch, then, curves obliquely upwards and then in the opposite direction to each other near the periphery. As the two branches ascend, they divide into about 6-8 bundles which occupy the lateral part of the ovary wall (Figs. 11 & 12). The branches may further divide as they ascend (Fig. 14). Two of these lying in the posterior direction of the ovary wall are the largest and more or less Y-shaped (Figs. 13-15, Y) and end in a rather inconspicuous style (Figs. 16-20,Y), while the other laterals appear to end in the ovary top at the very base of the style (Figs 16-20).



Figs. 1-10. *C. sativa* L. Fig. 1. Semidiagrammatic longitudinal section of the female flower showing vascular supply of the different floral parts. × 120. Fig. 2. T. S. of the inflorescence axis showing differentiation of the vascular supply of the bract and the flower pedicel. × 100. Figs. 3-10. Serial T. S. of the flower at the corresponding levels as indicated in Fig. 1. *br.*, bract supply; *p*1.........*p*9., receptacular bundles which give rise to perianth traces; *pd.*, pedicel supply.

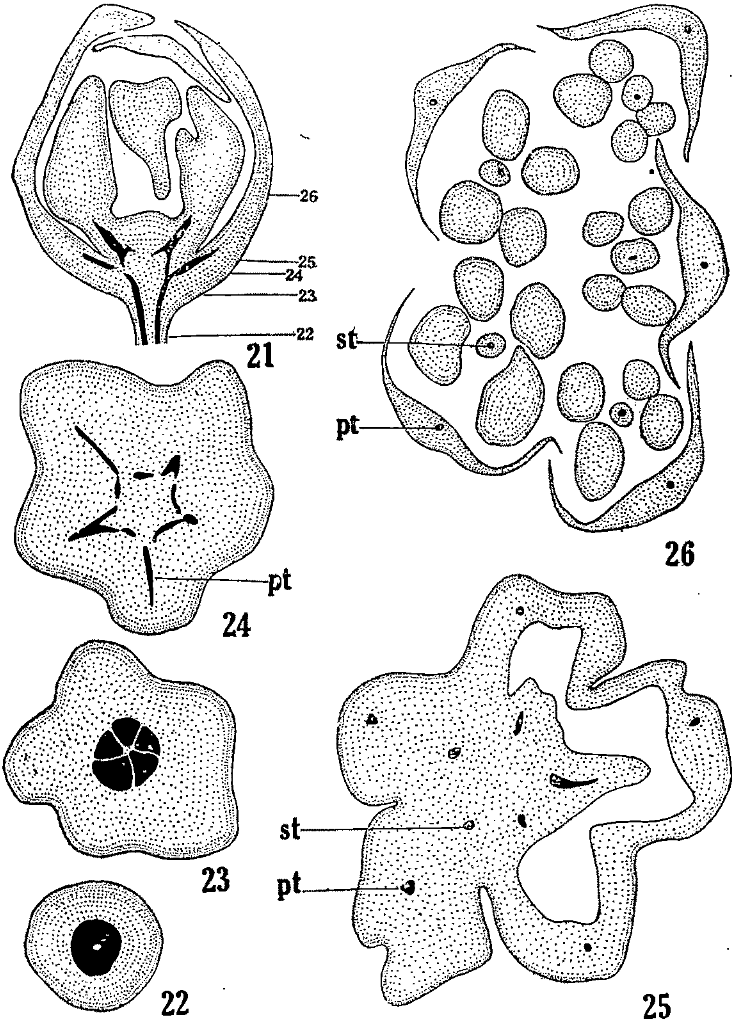
Simultaneously with the movement of the vascular bundle lb (Fig. 12), the remaining vascular tissue divides into two segments which move in the anterio-posterior direction (Figs. 11 & 12). The vascular trace going in the posterior direction becomes more or less amphicribral and occupies the position between the Y-shaped bundles in the ovary wall (Figs. 15-17,ov). It ascends upto the base of the funiculus where it bends down to enter the ovule and reaches its chalazal end (Fig. 1). Here it divides into a number of strands which ramify and arrange themselves into a ring at the chalaza (Fig. 1). Similar behaviour of the ovular supply is also recorded by Singh (1954) in *Ricinus communis*.



11-20. Serial T. S. of the flower at the levels 11-20 as marked in Fig. 1. × 100. *ad*,: anterior dorsal carpellary bundle; *ov*., ovular supply representing the common bundle for the dorsal carpellary bundle of the posterior carpel and the ventral carpellary; *s*., style; *y*., Y-shaped lateral bundles.

The second trace which is moving in the anterior direction ascends up and ends in the style (Figs. 13-20, ad). This represents the dorsal carpellary bundle of the anterior carpel. Vascular supply of the female flower of *Morus*, (5) helps us to understand the real nature of the amphicribral bundle entering the ovule. Here the ventral carpellary and the dorsal carpellary bundle of the posterior carpel have fused into a common strand running to more than half of their course as fused bundle. Higher up they divide into two again, the inner entering the ovule ,while the outer passes up as the dorsal carpellary bundle of the posterior carpel. In *Cannabis sativa* there has been a prolonged fusion of the dorsal carpellary and the ventral carpellary bundle ; and both of them, therefore, enter the ovule showing an extreme case of fusion of the dorsal carpellary bundle and the ventral carpellary bundle.

The vascular bundle in the lateral part of the ovary wall may be considered as the lateral bundles of the carpels as pointed by Bechtel (1). He has further showed a similar occurence of lateral bundles in *Celtis*. He has reported two lateral bundles in addition to two dorsal and one ventral carpellary bundle.



Figs. 21-26. *C. sativa* L. Fig. 21 Semidiagrammatic longitudinal section of the malel flower showing the vascular supply of the perianth and the stamens. x 90. Figs. 22-26. Seria T. S. of the flower at the corresponding levels 22-26 as marked in the Fig. 21. x 120. *pt.*, perianth trace, St. Stamen trace.

VASCULAR SUPPLY OF THE MALE FLOWER

Fig. 21 represents a longitudinal section of a male flower. The index-numbers denote the levels from which regions transverse sections have been drawn. The transverse section of the pedicel of the male flower at the level 22 shows a complete ring of vascular bundles (Fig. 22), which breaks up into five bundles at the level 23 (Fig. 23). Five traces then arise from the above mentioned five bundles to supply the five perianth leaves (Figs. 24-26, pt) and they remain undivided throughout. The remaining vascular tissue again organizes itself into five bundles and supply the five stamens (Figs. 25, 26, st). No vascular tissue is left in the centre after the supply to the stamens is given off, as noticed in *Morus*, (1, 5), nor is there any sign of a rudimentary pistil (Fig.21). These observations of the vascular supply of the male flower are, therefore, in complete confirmity with those of Bechtel (1).

DISCUSSION

The first structure to receive the vascular supply from the stele of the floral pedicel is the bracteole, and not the bract, as referred by Bechtel, who also found three vascular bundles entering the receptacle. Bechtel, however, feels that two of these bundles extend in the anterio-posterior direction as the dorsal carpellary bundles of the two carpels, while the third enters the ovule. My findings are at variance with those of Bechtel. The recepticular supply first organizes into a cylinder, before breaking up into three bundles. One of the bundles, which enters the ovule, is amphicribral while the other two collateral. The anterior one of these collateral bundles travels into the style, while the posterior one divides and forms a number of lateral bundles. Bechtel seems to have failed to make out the connections of these lateral bundles, probably due to his study of the younger flowers only. In *C. sativa* the differentiation of xylem takes place in the basipetal manner, in certain floral parts. Transverse sections of the younger flowers have shown only two bundles with xylem instead of three after the departure of bracteole trace. The presence of the third bundle could be made out with great difficulty because of its procambial nature. Sections at a comparatively higher level, however, showed clearly differentiated xylem.

Bechtel has referred to certain vascular tissue in the pedical of the flower, which the present author thinks to be receptacular bundles which might have come very close to the stelar region or some of them may even be scattered parts of the lateral bundles. Bechtel also found no connection of the perianth traces with that of the main stele while the observations of the present author show that they remain in the procambial condition throughout.

In *C. sativa* the perianth is extremely reduced only appearing normal in the younger flowers. As the flower grows old and matures into a fruit the perianth tissue becomes more or less crushed and, because the differentiation of xylem in the perianth is basipetal, the connections of the perianth traces remain undifferentiated into xylem and phloem throughout the life of the flower.

The exact mode of origin of the vascular bundles entering the perianth is not clear. They may all arise separately or only three traces may arise from the main stele. Each of these traces divide again into three to give rise ultimately to nine vascular bundles of the perianth. Bechtel has also suggested a more or less similar mode of origin of perianth supply in case of *Humulus*. He has assumed that the vascular supply to the perianth arises either as separate bundles from the main stele or as a single trace which divides and forms separate bundles.

SUMMARY

The paper deals with the floral anatomy of female and male flowers of *Cannabis sativa L.*

The Present investigation differs in several places so far as the vascular structure of the female flower, as described by Bechtel (1), is concerned. The study of the vascular anatomy of the male flower confirms his observations.

The pedicel of the female flower has ring of four vascular bundles, one of which passes out to the bracteole. The gamophyllous perianth shows a weak vascular supply of about 8-9 bundles. The main stele now becomes more or less cylindrical and then breaks up into a number of laterals, the anterior dorsal carpellary and a common bundle for the posterior dorsal carpellary and the ventral carpellary bundle. It is shown that the gynaeecium of *C. sativa* consists of two carpels, one of which is represented in an extremely reduced condition.

ACKNOWLEDGMENTS

The author is deeply indebted to Prof. Bahadur Singh for his kind guidance and suggestions throughout the course of the present investigation. His thanks are also due to Dr. R. K. Singh, Principal, B. R. College, Agra for facilities and encouragement.

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DEVELOPMENT OF ENDOSPERM AND EMBRYO IN *PHYLLANTHUS NIRURI* L.

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Johansen (1) and Johri & Kapil (2) have reviewed the literature concerning the embryo development in Euphorbiaceae. In the majority of forms studied, the development of the embryo follows the Onagrad type. In *Euphorbia preslii* (9) and in *Euphorbia rothiana* (6) the embryo development follows the Piperad type. Other types have not been reported but the present communication shows that the embryonic development in *Phyllanthus niruri* is of the Solanid type.

Material and Method

The material for the present investigation was collected from the Botanical garden, B. R. College, Agra, during the rainy season. Flowers and seeds were fixed in Formalin-acetic-alcohol. They were run through alcohol-xylol as well as tertiary-butyl-alcohol series and were embedded in paraffin. Sections (8μ-12μ in thickness) were stained with safranin-fast green and crystal violet erythrosin combinations.

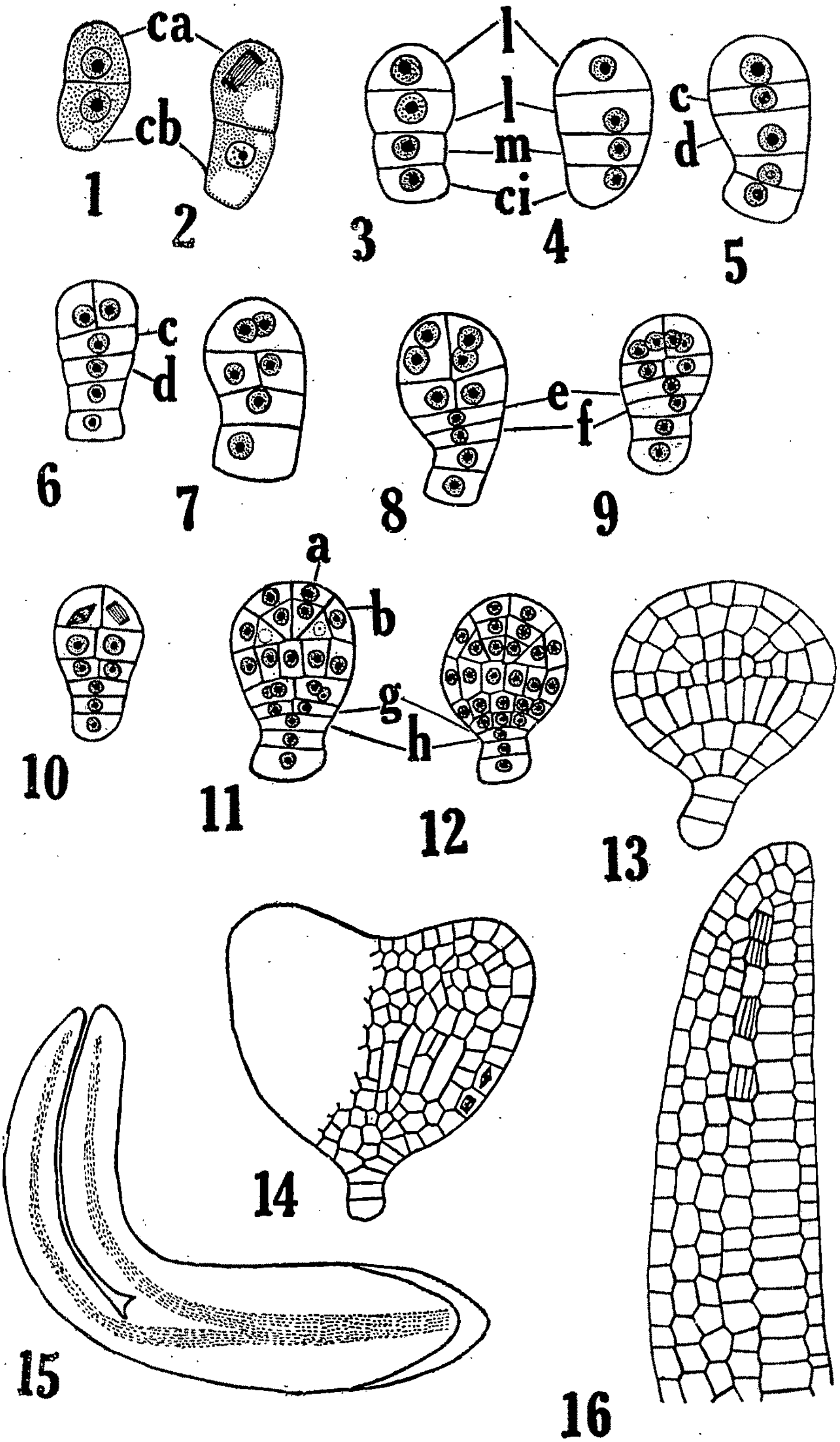
Endosperm

Development of the endosperm, as in *Ricinus communis* (4), and other species so far studied (2, 3, 7 & 8), is of free nuclear type. The primary endosperm nucleus divides earlier than the oospore. In the beginning the endosperm nuclei occupy the periphery of the sac and are distributed throughout its entire length. Wall formation starts from the micropylar side and proceeds towards the chalazal end. In the mature seed the endosperm is rich in food reserves.

Development of Embryo

The oospore divides by a transverse wall forming a two-celled pro embryo in the first cell generation (Fig. 1). The terminal cell *ca* and the basal cell *cb*, thus formed, again divide by transverse walls forming a linear tetrad in the second cell generation. These cells are designated as *l*, l^1, *m*, *ci* (Fig., 3 &4). Fig. 2 shows the cell *ca* undergoing transverse division.

In subsequent development of the pro embryo the tier *l* always appears to divide by a vertical wall. The two daughter cells, thus formed, are arranged in juxtaposed manner (Figs., 6 & 7). The tier l^1, which appears to divide earlier than the tier *l*, either divides by a transverse wall forming two superposed cells (Figs., 5 & 6, *c* and *d*), or by a vertical wall forming two cells arranged at right angles to those of tier *l* (Fig. 7). The two cells *m* and *ci*, derived from *cb*, do not divide and thus the proembryo consists of six cells either arranged in



Figs. 1-14. Stages in the embryo development. Fig. 15 Mature embryo. Fig. 16 part of the contyledon. Figs. 1-1 ×850. Figs. 9-13 × 650. Fig. 14 × 80. Fig. 15 × 400.

five tiers (Fig., 6) or in four tiers only (Fig. 7). The former arrangement appears to be more common.

In the next stage of development, each of the two cells of tier *l* divides by a vertical wall at right angles to the previous one forming four cells, usually known as the quadrant (Figs. 8 & 9). The upper cell *c*, of the two superposed cells formed from l^1, divides by a vertical wall with the formation of two juxtaposed cells, while the lower cell *d* divides by a transverse wall forming again two superposed cells (Figs. 8 & 9, *e* and *f*). The cells *m* and *ci* do not undergo any division. At this stage the proembryo consists of ten cells arranged in six tiers.

During further development of the proembryo, cells of the quadrant *l* do not divide by transverse but by oblique walls similar to that of *Morus indica* (5). The orientation of the walls appears to be such that the insertion of one end is at the transverse wall, separating the tiers *l* and *c* while that of the other end is approximately at the centre of the peripheral wall. (Fig. 10 shows oblique orientation of the spindle in the tier *l*). In the longitudinal plane of the proembryo these oblique walls appear to differentiate cells of two different shapes. The cells adjacent to the axis are quadrilateral, while the outer ones are triangular. These cells may be designated as *a* and *b* respectively (Fig. 11). The tier *l* now consists of four cells of *a* type and four of *b* type. In each of the *a* type cells the next wall formed is more or less transverse which forms an outer epidermal initial and an inner daughter cell (Fig. 11). The epidermal initial further divides only by anticlinal walls. The inner daughter cell again divides by a transverse wall and forms two superposed cells (Fig. 12). Figs. 11 & 12 show that *b* also divides periclinally into an outer epidermal cell and an inner cell which is triangular in shape like the parent cell. This inner cell is again divided periclinally forming an inner and an outer cell which represent the plerome and periblem initial of the cotyledons. From the tier *l*, on the whole, are derived the two cotyledons and the stem tip.

Each cell of the tier *c* divides by a vertical wall, perpendicular to the previous one, giving rise to four circumaxial cells. These four cells later divide by periclinal walls forming outer epidermal cells and inner cells. The inner cells further divide by periclinal wall differentiating into periblem and plerome initials (Fig. 12). From this tier is derived the hypocotyledonary region of the embryo.

The next lower tier *e*, by two vertical walls perpendicular to each other, gives rise to four circumaxial cells (Fig. 11). This tier ultimately contributes in the formation of root tip and a part of the root cap.

The tier *f* divides transversely and forms two superposed cells *g* and *h*. These contribute, after few divisions, in the formation of remaining root cap (Figs. 13 & 14).

The suspensor is usually two celled.

MATURE EMBRYO

In a well developed seed the embryo occupies nearly its whole length and is slightly curved (Fig. 15). The embryo shows a differentiation into two cotyledons, a plumule, hypocotyl, root tip and the root cap.

The plumule consists of a mass of meristematic cells and lies between the two large cotyledons. The hypodermal layer below the inner epidermis of the cotyledons shows elongation in a plane at right angles to the embryo axis (Fig. 16), and forms the palisade cells. The other ground cells of the cotyledons are similar in structure and do not show any differentiation. The vascular elements present in this organ are of pro-cambial nature and are continuous with the pro-cambial strand of the hypocotyl. The root cap is well developed and covers the end of the root tip.

The embryonomic formulae* in the case of *Phyllanthus niruri* may be given as follows :—

I. First cell generation.
Proembryo of two cells
disposed in two tiers.
$ca=\mathrm{pco}+\mathrm{pvt}+\mathrm{phy}$
$\mathrm{icc}+\mathrm{iec}+\mathrm{co}$
$cb=\mathrm{s}$

II. Second cell generation.
Proembryo of four cells
disposed in four tiers.

$l=\mathrm{pco}+\mathrm{pvt}$
$l'=\mathrm{phy}+\mathrm{icc}+\mathrm{iec}+\mathrm{co}$

$$\left.\begin{matrix} m \\ ci \end{matrix}\right\rangle \mathrm{s}$$

III. Third cell generation.
Proembryo of six cells disposed in five tiers normally.
$l=\mathrm{pco}+\mathrm{pvt}$
$c=\mathrm{phy}+\mathrm{icc}$
$d=\mathrm{iec}+\mathrm{co}$

$$\left.\begin{matrix} m \\ ci \end{matrix}\right\rangle \mathrm{s}$$

IV. Fourth cell generation.
Proembryo of ten cells disposed in six tiers.
$l=\mathrm{pco}+\mathrm{pvt}$
$c=\mathrm{phy}+\mathrm{icc}$
$e=\mathrm{iec}+\mathrm{co}$(in part)
$f=\mathrm{co}$

$$\left.\begin{matrix} m \\ ci \end{matrix}\right\rangle \mathrm{s}$$

*The embryonomic formulae and abbreviations are mostly after Johansen (1).

SUMMARY

The development of the endosperm is of free-nuclear type and the wall formation starts from the microphylar side and proceeds towards the chalazal end.

The embryo development is of Solanad type. The basal cell forms only the suspensor the embryo proper being derived from the terminal cell only.

At maturity the embryo is differentiated into two large cotyledons, plumule, hypocotyl, root tip and root cap. It is slightly curved in mature seed.

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BEHAVIOUR OF POLLEN-TUBE GROWTH IN SOME INTERSPECIFIC CROSSES IN THE GENUS *LINUM*

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Introduction

It is well known that crosses between different varieties of the same species are more successful than those between types which are widely related. While it is ordinarily possible to improve crop plants through intervarietal hybridization, it is often necessary to resort to wide crosses for improving characters as disease, pest, and drought resistance, adaptability to special conditions of growth, etc. Until recently such wide crosses were not considered as a practical method, because in many cases the crosses were either difficult to make or if they could be made the hybrids turned out to be partially or wholly sterile. The causes of such failures have been recently investigated (1, 2, 5) and have been termed as incompatibility reactions, which may be classified in the following three groups :

1. Inability of the pollen-tube to function normally in a foreign style (Prefertilization causes).
2. Failure of fertilization.
3. Inability of the zygote or of the endosperm to develop or arrest of their development before maturity (Postfertilization causes).

Linum usitatissimum L. is a common cultivated crop grown both for oil and fibre. Other species of the genus which also differ in their chromosome number do not cross among themselves except *L. aungustifolium* Will En., which crosses easily with other species (3). In the present studies an attempt has been made to find out the behaviour of pollen tube growth to determine only the prefertilization causes of incompatibility in the selected material.

Material and Methods

The material for the present study consisted of the following five species of *Linum* : 1. *Linum usitatissimum* Linn. (n=15) 2. *L. grandiflorum* Desf. (n=8) 3. *L. marginale* Cunningh. (n=15) 4. *L. aungustifolium* Willd. En. (n=15) 5. *L. africanum* L. (n=16)

The material was obtained from the Botany Division of Indian Agricultural Research Institute and was sown in separate lines. When plants came in flower the crosses were made in following combinations.

1. *L. usitatissimum* × *L. grandiflorum* and its reciprocal.
2. *L.* „ × *L. marginale* and its reciprocal.
3. *L.* „ × *L. aungustifolium* and its reciprocal.
4. *L.* „ × *L. africanum* and its reciprocal.

Each species was also selfed. The carpels both in the cases of cross combinations and in self were harvested at intervals of 12 hrs., 24 hrs., 48 hrs., and 78 hrs. They were then placed in F. A. A. solution for 24 hrs. and then transferred to 70% alchohol. The carpels were stained in a mixture of following stain.

1. 80 c.c. of 1% acqueous solution of acid fuchsin.
2. 20 c.c. of 1% „ „ „ light green.

After staining the carpels were washed in running water and then placed in Lactic acid and kept there for 24 hrs. Thus treated carpels were taken on a clean slide and ovaries removed from the lowermost base of the style and five styles of each carpels were separated from one another and kept at equal distance laterally. A few drops of Lactic acid were added to ensure proper mounting with round coverslip No. 1 on the material which spread out in the slide by the application of gentle pressure on the coverslip with needle. The slide was ringed with Canada Balsam.

From the microscopic slides thus prepared the following observations were taken. 1. Length of the style. 2. Number of pollengrains over the stigma. 3. Number of pollengrains germinated. 4. Normal pollen-tubes within the style. 5. Abnormal pollen-tubes within the style. 6. Length reached by normal pollen tubes.

In the observation no.6 three arbitrary classes were made where-in :—

1. Class No. A—Those pollen-tubes were grouped which have only germinated over the stigma but have not travelled below that region.
2. Class No B—Consisted of that group of pollen-tubes which have travelled upto the middle of the style.
3. Class C—Consisted of the pollen tubes which have passed the middle line and had reached or were reaching the base.

The data in different tables are the average of observations taken in 20 styles (Four carpels).

Camera lucida drawings were made with 5x eye piece at stage level of one representative style in each case.

EXPERIMENTAL RESULTS

A. *Observations over crossed styles and also their reciprocals :*

Cross No. 1.

L. usitatissimum (n=15) *L. grandiflorum* (n=8)

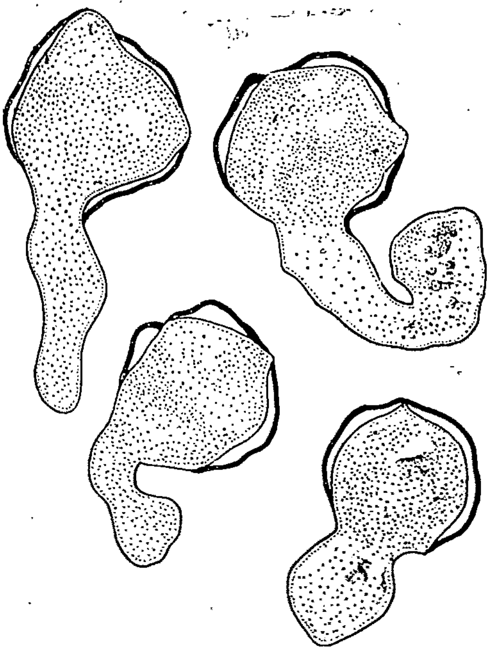
In this cross within 12 hours after pollination 78 percent of pollengrains germinate and 97.9 percent of them are normal. The highest germination percentage is in the case of 12 hours harvesting (Table I). Most of the pollentubes reach the middle of the style (B group) within 12 hours. The pollentube in C group are seen only after 24 hours interval or later (Plate III, Fig. 1 L. R. 3).

The number of abnormal tubes during any time interval is very few.

Reciprocal :

L. grandiflorum (n=8) × *L. usitatissimum* (n=15)

Here the percentage of germination of pollen grains of *L. usitatissimum* over the stigma of *L. grandiflorum* is poor right from 12-hour interval upto 72-hour interval. The highest percentage of germination has been obtained in 48-hour interval where it is 43.4 (Table I). The progress of germinated pollen tubes is also poor (Plate I, fig. 1 U. R.). None of them has reached even the middle of the style. The percentage of abnormal tubes has increased and many abnormal tubes are seen over the stigmatic region.



VARIOUSTYPES OF ABNORMALITIES IN THE POLLEN TUBES X 900

Cross No. 2:

L. usitatissimum (n=15) × *L. marginale* (n=15)

In this cross 27.2 percent pollen grains germinate within 12 hours after pollination and 58 percent of them are normal. The highest germination (58·9) is reached in 24-hour interval (Table 2). Most of the pollen tubes reach the middle of the style within 12 hours. The pollen tubes in C group are seen only in 24-hour interval and later (Plate III, Fig. 2 U. R. 3). The number of abnormal pollen tubes is few.

Reciprocal :

Here after 12 hours of polination 53.7 percent of pollen grains have germinated and as more time passes the percentage of germination goes down. After 72 hours it remains only 35.2 percent (Table 2). The progress of germinated pollengrains is so rapid that they reach the base of the style at the end of 12 hours interval (Plate III, fig. 2 L. R. 2). The percentage of abnormal pollen tubes is negligible in all the four intervals.

Cross No. 3 :

L. usitatissimum (n=15) × *L. aungustifolium* (n=15)

In this cross upto 12 hours after pollination 24.8 percent of the pollen grains germinate and 74.9 percent of them are normal. The highest germination has been observed in the case of 24-hour harvesting when 36.2 percent spores have germinated. (Table 3). Most of the pollen tubes reach the base of the style within 48 hours. (Plate III Fig. 3. U. R. 4.). The number of abnormal pollentubes during any time interval is very low.

Reciprocal :

L. aungustifolium (n=15) × *L. usitatissimum* (n=15)

The percentage of germination of the pollen grains of *L. usitatissimum* over the stigma of *L. aungustifolium* is nearly equal in all the time intervals right from 12-hour interval upto 72 hours. The progress of pollen tube germination is such that they reach the bottom of the style in 48 hours. The number of abnormal pollen tubes is few.

TABLE I. Behaviour of pollen tubes in the style during different time intervals in cross *L. usitatissimum* × *L. grandiflorum* and its reciprocal.

Treatment	Time Interval (hours)	Average length of style (mm.)	No. of normal pollen grains over the stigma	Germinated pollen grains (p. c.)	Normal pollen tubes within the style (p. c.)	Abnormal pollen tubes within the style (p. c.)	Maximum length reached by the normal pollen tubes. (groups)
Cross	12	4.3	47.8	78.00	97.90	2.60	B
L. usitatissimum	24	4.3	24.8	60.80	88.90	9.10	C
L. grandiflorum	48	4.3	45.8	46.00	94.60	5.10	C
	72	4.3	32.6	72.80	90.50	9.20	C
Reciprocal	12	6.75	34.30	21.50	60.3	9.4	A
L. grandiflorum ×	24	6.75	51.00	23.00	75.2	44.0	A
L. usitatissimum	48	6.75	39.40	43.40	27.5	71.9	A
	72	6.75	44.60	16.50	8.0	72.4	A

TABLE II. Behaviour of pollen tube in the style during different time intervals in cross *L. usitatissimum* × *L. marginale* and its reciprocal.

Treatment	Time interval (hours)	Average length of style (mm.)	No. of normal pollen grains over the stigma	Germinated pollen grains (percent)	Normal pollen tubes within the style (percent)	Abnormal pollen tubes within the style (percent)	Maximum length of normal pollen tubes (groups)
Cross	12	4.3	14.9	27.2	58.0	24.9	B
L. usitatissimum	24	4.3	38.1	56.9	88.5	11.0	C
× *L. marginale*	48	4.3	29.1	28.2	95.7	4.3	C
	72	4.3	18.2	33.3	93.3	3.2	C
Reciprocal	12	4.4	42.5	53.7	99.0	0.9	C
L. marginale	24	4.4	26.2	48.0	97.4	4.4	C
× *L. usitatissimum*	48	4.4	35.2	42.3	94.0	0.1	C
	72	4.4	35.8	35.2	100.0	—	C

Cross No. 4 :

L. usitatissimum (n=15) × *L. africanum* (n=16)

In this cross 48 percent of the pollen grains germinate within 12 hours of pollination and most of them reach the base of the style within the same time interval (Plate III Fig 4, U. R. 2). At the end of 72 hours the percentage of germination has gone up to 61.4. The percentage of normal pollen tubes within the style is high, the highest being in 24-hour harvesting. The maximum germination of 61.4 percent is obtained in the case of 72-hour harvesting. The percentage of abnormal pollen tubes in 12, 24, and 72 hours has been 17.2, 7.5, and 14.1 percent respectively (Table IV).

Reciprocal :

L. africanum (n=16) × *L. usitatissimum* (n=15)

The percentage of germination of pollen grains of *L. usitatissimum* over the stigma of *L. africanum* is poor. The highest figure for germination is 43.9 percent reached in 24 hours. (Table 4). The progress of pollen tube in the style is slow because even at the end of 72 hours the tubes have travelled hardly upto the middle of the style. They seem to be arrested in the way and none of them has reached the base of the style (Plate III fig 4, L. R. 5).

B. *Observations on selfed styles* :

1. *Linum usitatissimum* Linn. (n=15)

After 12 hours of selfing 33.9 percent of the pollen grains germinate and reach the base of the style within the same interval. The highest percentage of germination is obtained in the case of 12-hour harvesting (Table V). No abnormality in pollen tubes is observed.

2. *L. grandiflorum* Desf. (n=8)

In this case 33.6 percent of the pollen grains germinate within 12 hours of selfing and the tubes reach the base of the style within the same time limit. The highest percentage of germination is in 12 hours of selfing. (Table V). All the observed pollen tubes have been normal.

TABLE III. Behaviour of the pollen tube in the style during different time intervals in cross *L. usitatissimum* × *L. aungustifolium* and its reciprocal.

	Time interval (hours)	Average length of style (mm.)	Average no. of normal pollen grains over the stigma	P. C. of germinated pollen grains	P. C. of normal pollen tubes within the style	P. C. of abnormal pollen tubes within the style	Maximum length reached by the normal pollen tubes.
Cross	12	4.3	37.2	24.8	74.9	5.0	B
L. usitatissimum	24	4.3	24.2	32.6	82.6	7.3	C
× *L. aungustifolium*	48	4.3	32.3	41.1	79.1	10.8	C
	72	4.3	25.0	28.6	25.0	—	C
Reciprocal	12	4.2	45.2	28.0	91.3	9.8	A
L. aungustifolium	24	4.2	27.7	24.9	98.0	2.0	A
× *L. usitatissimum*	48	4.2	31.1	28.4	98.4	1.6	C
	72	4.2	30.8	28.7	73.8	5.9	C

TABLE IV. Behaviour of the pollen tubc in the style during different tlme intervals in cross *L. usitatissimum* × *L. africanum* and its deciprocal.

	Time interval (hours)	Average length of style (mm.)	Average number of normal pollen grains over the stigma	Percentage of germinated pollen grains	P. C. of normal pollen tubes within the style	P. C. of abnormal pollen tubes within the style	Maximum length reached by the normal pollen tubes
Cross *L. usitatissimum* × *L. africanum*	12	4.3	24.0	48.0	53.2	17.2	C
	24	4.3	26.9	52.7	92.5	7.5	C
	48	4.3	52.5	58.8	83.3	11.8	C
	72	4.3	51.6	61.4	75.2	14.1	C
Repcirocal *L. africanum* × *L. usitatissimum*	12	4.3	33.8	29.3	46.0	41.2	A
	24	4.3	41.4	43.9	79.1	20.3	B
	48	4.3	23.8	37.4	66.5	28.0	B
	72	4.3	35.6	7.2	24.1	25.8	B

3. *L. marginale* Cunningh. N. Holl. (n=15)

At the end of 12 hours after pollination 23.2 percent of pollen grains germinate but their progress is slow as they reach the middle of the style only after 24 hours and at the base of the style after 48 hours (Table 5). No abnormal pollen has been observed in this case.

L. aungustifolium Willd En. (n=15)

After 12 hours of self pollination 31.4 percent of the pollen grains germinated and reached the middle of the style within the same time. The pollen tubes in C group are seen only during the 12-hour interval and later (Table 5). The highest germination percentage is in the case of 14-hour interval. All the pollen tubes appear normal.

5. *L. africanum* Linn. (n=16)

Here the pollen grains appear to take more time for germination. It is only after 48 hours of selfing that the germination starts and in 48 hours harvesting pollen tubes appear to reach the middle of the style. It takes them nearly 72 hours in this case to reach the base of the style (Table 5). Although progress of pollen tubes is slow they all appear normal,

TABLE V. Behaviour of pollen tubes in selfed styles after different time intervals.

bservations	L. usitatissimum				MATERIAL L. grandiflorum				SELFED L. marginale				L. aungustifolium				L. africanum			
					HOURS				AFTER				POLLINATION							
	12	24	48	72	12	24	48	72	12	24	48	72	12	24	48	72	12	24	48	72
verage length of the style (mm.)	4.3	4.3	4.3	4.3	6.7	6.7	6.7	6.7	4.4	4.4	4.4	4.4	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3
verage num- er of pollen ains over the igma	29.5	20.3	29.7	20.3	33.8	51.4	55.8	54.4	23.7	22.0	22.2	20.6	18.5	37.5	23.8	22.7	40.0	41.4	30.5	22.1
ercentage of erminated pol- n grains	33.9	20.6	33.0	29.5	33.6	27.2	17.4	23.0	23.2	19.6	23.0	21.3	31.4	37.6	21.8	27.8	24.8	14.5	23.0	19.9
ercentage of ormal pollen ibes within ie style	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
ercentage of normal pollen ibes (swollen burst) with- the style	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
laximum len- h reached by ormal pol- n tubes (groups)	C	C	C	C	C	C	C	C	A	B	C	B	B	C	C	C	A	A	B	C

DISCUSSION AND CONCLUSIONS

Among many causes of failure in accomplishing wide crosses the faulty germination of pollen or growth of pollen tubes is important. Although it is probable, it is not certain that normal pollen tube growth will be followed by normal fertilization, and normal seed development afterwards in wide crosses. In many cases the compatibility of the two species differs in reciprocal crosses and often when both crosses can be easily made the quality of the resulting seed is better in one than in the reciprocal cross. After self-fertilization or crosses between types with the same chromosome number the pollen tube grows in a style having twice as many chromosomes as pollen grains. In crosses between parents with different chromosome numbers this relation between style and pollen tube, 2 : 1, is upset which may result in the failure of the pollen tube into pass through the style.

In cross *L. usitatissimum* × *L. grandiflorum* the pollen tube growth is normal and it takes about 48 hours for the male parent to send its pollen tubes upto the base of the mother plant style. The high chromosome number plant does not offer any obstacle in the style for the low number chromosome plants pollen tube. But in the reciprocal where it is the question of low × high chromosome number association the relation 2:1 between the style and the pollen tube is upset and as a reult the pollen tubes fail to travel through the style successfully. Even after 72 hours of pollination they have not only failed to reach the base of the style but the percentage of abnormal pollen tubes in the style has also increased.

Similarly when *L. usitatissimum* is female and *L. africanum* male the progress of pollen tubes appears to be normal and they reach the base of the style in as much time as is taken by the pollen tubes of *L. usitatissimum* in its own style. But in the reciprocal when L. africanum is and *L. usitatissimum* the pollen tube growth is obstructed, the percentage of abnormal pollen tubes increases and even after 72 hours of pollination the tubes do not reach the base of the style. In such cases, as in many other dicotyledons (4, 6, 7, 8), the rule seems to be that a relatively high chromosome number of the style does not inhibit the growth whereas in the opposite direction the pollen tubes are checked.

In the other crosses *L. usitatissimum* × *L. marginale* and *L. usitatissimum* *L. angustifolium* and their reciprocal the pollen tube growth appears to be as normal as in their self matings. Here the relation of 2:1 between the style and pollen tube does not seem to upset and hence the behaviour of pollen tube growth in foreign style is normal.

SUMMARY

Five species of *Linum* were intercrossed and the behaviour of pollen tubes in the styles was studied.

In crosses *L. usitatissimum* × *L. grandiflorum* and *L. usitatissimum* × *L. africanum* the behaviour of pollen tube growth in the foreign style was normal

but in the reciprocal crosses the progress of pollen tubes was slow and many abnormal pollen tubes were developed.

In crosses *L. usitatissimum* × *L marginale* and *L. usitatissimum.* × *L. aungustifolium* and their reciprocal the pollen tube growth is normal.

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PLATE III

A. N. KANNA *et al.*: Pollen tube growth in *Linum*

Fig. 1. *Upper row.*

1. L. Grandiflorum—12 hours after self pollination.
2. L. grandiflorum × L. usitatissimum—12 hours after pollination.
3. L. grandiflorum × L. usitatissimum—12 hours after pollination.
4. L. grandiflorum × L. usitatissimum—48 hours after pollination.

Lower row.

1. L. usitatissimum—12 hours after self pollination.
2. L. Usitatissimum × L. grandiflorum—12 hours after pollination.
3. L. usitatissimum × grandiflorum—24 hours after pollination.

Fig. 2. *Upper row.*

1. L. usitatissimum—12 hours after self pollination.
2. L. usitatissimum × L. marginale—12 hours after pollination.
3. L. usitatissimum × L. marginale—24 hours after pollination.
4. L. usitatissimum × L. marginale—48 hours after pollination.

Lower row.

1. L. marginale—12 hours after self pollination.
2. L. marginale × L. usitatissimum—12 hours after pollination.

Fig. 3. *Upper row.*

1. L. usitatissimum—12 hours after self pollination.
2. L. usitatissimum × L. aungustifolium—12 hours after pollination.
3. L. usitatissimum × L. aungustifolium—24 hours after pollination.
4. L. usitatissimum × L. aungustifolium—48 hours after pollination.

Lower row.

1. L. aungustifolium—12 hours after self pollination.
2. L. aungustifolium—24 hours after self pollination.
3. L. aungustifolium × L. usitatissimum—12 hours after pollination.
4. L. aungustifolium × L. usitatissimum—24 hours after pollination.
5. L. aungustifolium × L. usitatssimum—48 hours after pollination.

Fig. 4. *Upper row.*

1. L. usitatissimum—12 hours after self pollination.
2. L. usitatissimum × L. africanum—12 hours after pollination.

Lower row.

1. L. africanum—12 hours after self pollination
2. L. africanum—24 hours after self pollination.
3. L. africanum—48 hours after self pollination.
4. L. africanum × L. usitatissimum —24 hours after pollination.
5. L. africanum × L. usitatissimum—72 hours after pollination.

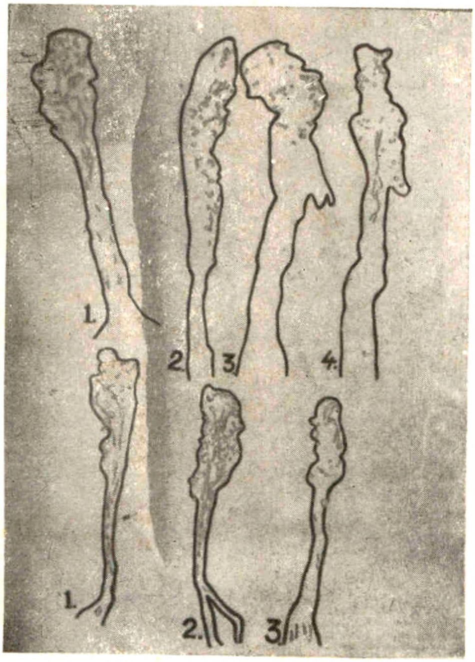

Fig. 1

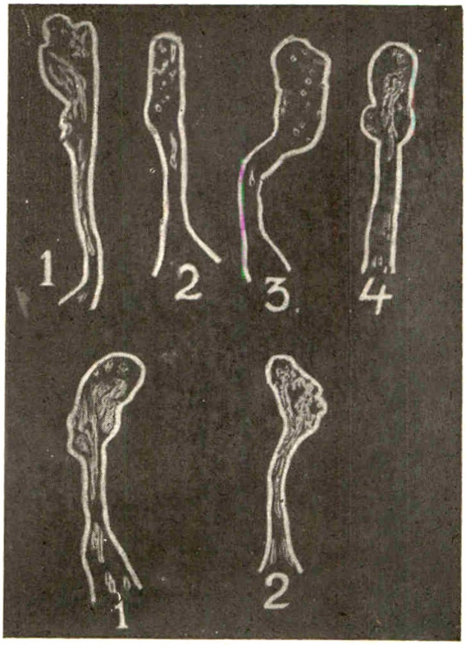

Fig. 2

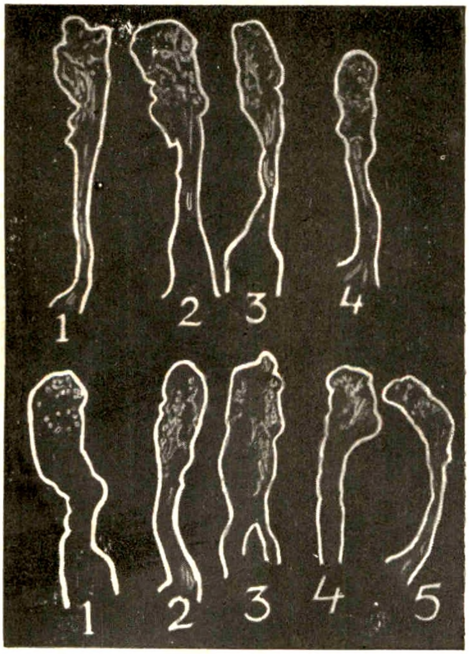

Fig. 3

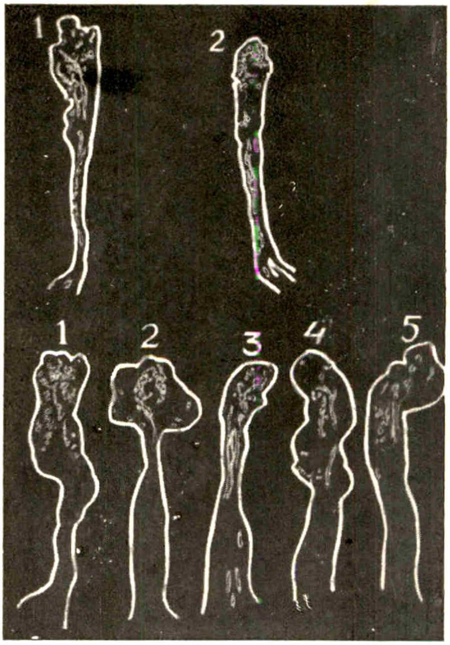

Fig. 4

THE LIFE-HISTORY AND ECOLOGY OF THE SHORT-HORNED GRASSHOPPER *Parahieroglyphus bilineatus* BOLIVAR (ORTHOPTERA : ACRIDIDAE)

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I. INTRODUCTION

Bolivar (1912) recognised *Parahieroglyphus bilineatus* as a well defined species. Uvarov (1922) in his revision of the rice grasshoppers showed that this species is not the micropterous form of *Hieroglyphus banian* Fabricius as believed by Lefroy (1909, pp. 86), and Kirby (1914, pp. 203). Males are characterized by having well-marked trilobed cerci while in females the cerci are simple.

Although a good deal of work on the life-history and ecology of *Hieroglyphus* and allied species has been done (Lefroy, 1909; coleman & kuhni Kannan, 1911; Coleman, 1914; Husain & Roonwal, 1933; Rao & Cherian, 1940 and Roonwal, 1945, 1952.), nothing is known about *Parahieroglyphus bilineatus* except its mode of copulation which has been studied by Katiyar (1952).

In the present paper is given an account of the life-history and ecology of *Parahieroglyphus bilineatus* Bolivar.

ACKNOWLEDGMENTS

This work was carried on in the Entomology Branch of the Forest Research Institute, Dehra Dun, under the supervision of Dr. M. L. Roonwal, the Forest Entomologist. The author is much indebted to him for the suggestions and advice given by him during the course of this work.

II. MATERIAL AND BREEDING TECHNIQUE

In early September, 1951, a large number of nymphs of *Parahieroglyphus bilineatus*, from 2nd to the 5th stages, were collected from the bamboo area in the New Forest Estate of the Forest Research Institute, Dehra Dun. They were caged in a large trough with a 7·5-10 cms. layer of sandy-loam. In a few days the nymphs became adults in the experimental cage in the Insectary. Egg-pods were obtained from them from the 2nd week of September to 1st week of October, 1951. Later on, 25 egg-pods were kept under a 4-inch thick layer of soil (moistened with water once, and sometimes twice a week) in an earthen flower-pot which was covered with fine wire-gauze. The maximum number of nymphs hatched out in the 1st and 2nd weeks of June next year. The hatched nymphs were kept in two wooden cages with wire-gauze sides measuring about 60 x 30 x 30 cms. They were supplied daily with fresh, tender grass which was kept dipping in a bottle of water. The breeding was carried out in the Insectary at a room temperature of 73°—92° F, from September to the middle of December.

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For observation of the duration of stages, etc., some hoppers of the 1st stage were kept individually in glass tubes (about 15 x 3.8 cms.) fitted with corks having muslin covered hole and fed on green grass every day. Side by side with laboratory breedings, records of field observations were also maintained from September, 1951 to December, 1954 (Tables 1-4).

III. HABITS AND LIFE-HISTORY

(a) *Habits*

The adults and hoppers of *Parahieroglyphus bilineatus* are always observed regregated and feed on green vegetation individually; this habit is unlike *Aularches punctatus* which congregates in masses on tree tops and bush tops to bask in the sun (Katiyar, 1955). Unlike species of *Hieroglyphus*, the present species occurs in one form only, *viz.*, the short-winged or micropterous form, which is unable to fly much; but the males as well as the females are very active in hopping. The activity of hopping is definitely increased during the hours of sunshine. In the forenoon nymphs as well as adults are seen on the tops of paddy, maize and other grasses, while in the afternoon, when the temperature rises, the insects come down for shade and sit near the roots of plants or on the surface of the soil. Copulation has been described in detail by Katiyar (1952).

(b) *Oviposition*

Oviposition was recorded from September 12th to October 8th, in 1951; from September 10th to October 4th, in 1952; and September 18th to October 10th, in 1953. The maximum number of ovipositions were observed during the 2nd and 3rd weeks of September in the Insectary, and from September 20th to October 4th in the field.

Seven to fifteen days after copulation, the females are noticed making holes in the soil with their ovipositor. After making one or two trial holes, the hole for oviposition is made. Almost all the females insert the abdomens slowly into the moist or dry soil as the case may be (in the cages). They first make an angle of 30°-40° with their abdomen on the surface of the soil. Later on, the females push themselves into the burrows upto the metathoracic margin under the soil and then make an angle of 55°-65° on the surface of the soil.

The act of oviposition lasts usually for 2-3½ hours, although in a few cases it lasted only for 1 hour 35 mins. After oviposition the females appear to be exhausted and start feeding very quickly.

Females may lay eggs as many as 3 to 5 times in their life-time; they usually die after their third or succeeding oviposition. In the first two lots, the egg pods do not show much difference in the number of eggs, the number being about 38-40 and 34-38 eggs in the first and second ovipositions respectively. In the succeeding layings they vary as follows: in third, 32-36; fourth, 30-35; and fifth, 28-33 eggs. There is an average of about 33.1 eggs per pod (Table 4).

The egg-pods were dug out from 3.2 to 7.1 cms. below the surface of the sandy-loam in the Insectary cages. In fields, they occurred from 2.5 to 6.4 cms. below the soil surface in sandy-loam along the sides of trodden paths in the bamboo experimental area in New Forest; very close to the high base of the paths and margins in paddy fields; and along cart-routes in the Bibiwala forest near *Kans* and other high grasses.

(c) *Egg-pods and eggs* (fig. *a*).

The egg-pods are about 1.2-1.45 cms. long and 0.45-0.58 cm. wide. They are almost straight, short and usually broad in the middle. The basal end is rounded while the apical end is flat with a very hard smooth concave cap. The frothy layer above the cap usually disintegrates. The outer wall is composed all around of thick, hard and dirty dark- brown layer. Fine particles of sand and small stones stick to the surface of the wall. Internally the secreted material is dirty or greyish brown.

The lower-most set of eggs is arranged vertically at right angles to the base of the pod, while the remaining eggs lie slanting towards the wall of the pod. In every case the micropylar pole of the egg points towards the base of the pod. In the middle region of the egg-pod, there is a thick lining of dense hard secreted material lying inbetween the eggs.

The eggs are subcylindrical, usually curved in the middle and sometimes only at the micropylar end. The anterior pole is rounded and the posterior pole somewhat tapering. The eggs vary in length from 3.8-4.5 (average 4.15 mm.), and in maximum width from 0.9-1.2 (average 1.05-mm.). With the development of the embryo the eggs gradually increase in size; the embryonic eyes become conspicuous in every egg before hatching.

(*d*) *Hatching*

Hatching may occur next year from the end of May to the beginning of July and lasts for about 6-7 weeks. The exact period varying from year to year, depending upon the weather conditions, as recorded in the following years in Dehra Dun:—Egg-pods obtained from the field in October, 1951, hatched from June 6th to July 1st, in 1952; those obtained, in 1952, hatched from June 9th to July 4th, in 1953; and those obtained in 1953, hatched from May 30th to July 2nd, in 1954.

(*e*) *Moulting*

Parahieroglyphus bilineatus Bolivar undergo six moults in both sexes; this was recorded in the Insectary cages (Table 3) as well as in the field. The duration taken by each stage is as follows:—1st stage, 11-13 days; 2nd stage, 10-14 days; 3rd stage, 14-19 days; 4th stage, 12-17 days; 5th stage, 14-18 days; 6th stage, 17-25 days. Males become adults 10-16 days earlier than females.

IV. THE NYMPHAL STAGES

(*a*) *Description of the stages*

(figs. *b-h*).

The different stages are briefly described below:—

First stage :

General.—Freshly hatched nymphs light fuscous, later on changing to pinkish yellow. Ventral surface a little greenish with numerous minute irregular black dots all over body and legs. *Head*: Light fuscous, with numerous blackish dots. Laterally with two definite rows of dots, one starting from the middle and the other a little below the eyes, and running to the thorax. *Legs*: Two anterior pairs fuscous with a few blackish dots on outer aspect, hind pair fuscous with rows of black dots on femur on outer aspect. Two rows of spines on tibia 7-9 on outer side, 10-11 on inner side. *Antennae*: Whitish with black dots on joints (for fuller description see Katiyar, 1953). *Wings*: Rudiments in the meso- and metathorax quite indistinct. *Cerci*: In females thin but conspicuous; in males globular at base. Females with rudimentary buds of ovipositor on eighth abdominal sternum, while genitalia in males rounded, in some having a notch on the rounded supra-anal plate. Average length of males, 5.2 mm.; females, 7.08 mm. (fig *b*)

Second stage:

Nymphs pinkish dorsally, greenish yellow ventrally; the numerous black dots more conspicuous. Rudimentary wing-pads "half fan-shaped" on meso- and metathorax. Cerci of females do not show any further development; in males, bifurcated. Subgenital plate of females show valves of ovipositor; in males the notch becomes more or less rounded. Average length of males 7.8 mm.; females 9.9 mm.

Third stage:

Nymphs usually pinkish. Numerous irregular dots reduced to a few brownish dots on the pro-meso-and metathorax only. Small patches become conspicuous in two to three rows on the lateral sides of abdomen. *Head:* Pinkish green; having, instead of two lateral rows of dots, 3-4 longitudinal dirty white bands. *Legs*: Number of dots on two anterior pair are reduced; on hind legs two blackish longitudinal streaks with 3-4 rows of dots in between them on the outer aspect of the femur. Number of dots in two rows of spines as before, though they increase in size. Rudimentary wing-pads easily visible (triangular on mesothorax and rounded on metathorax) pointing downwards; with no venation. Subgenital plates of male become V-shaped and protruded a little beyond last abdominal segment; the two pairs of ovipositor valves become more conspicuous. Cerci of males show two clear lobes and an indication of third. In females these are simple though increase in size. Average length of males 12.6 mm.; females 14.4 mm.

Fourth stage:

General colour: Testaceous-green. The dots and the patches on the body more definite. *Head*: Pinkish green with only longitudinal bands clear. *Legs*: Two anterior pairs with few brownish black dots; in the hind-leges longitudinal lower streaks and 3-4 rows of dots above become more definite. *Wing-pads*: More clear, pointing downwards; only some indication of veins. Male genitalia extending much beyond the supra-anal plate. In females, valves of ovipositor also extending much beyond apex of supra anal plate. Average length of males 14.6 mm.; females 17.8 mm.

Fifth Stage:

General colour: Greenish-pink; all dots and markings more prominent. *Wing-pads*: Now turned upwards and extent posteriorly up to beginning of the lst abdominal segment, with a lateral blackish line extending from the thoracic region upto the end of elytron. Average length of males 17.9 mm.; females 20.7 mm.

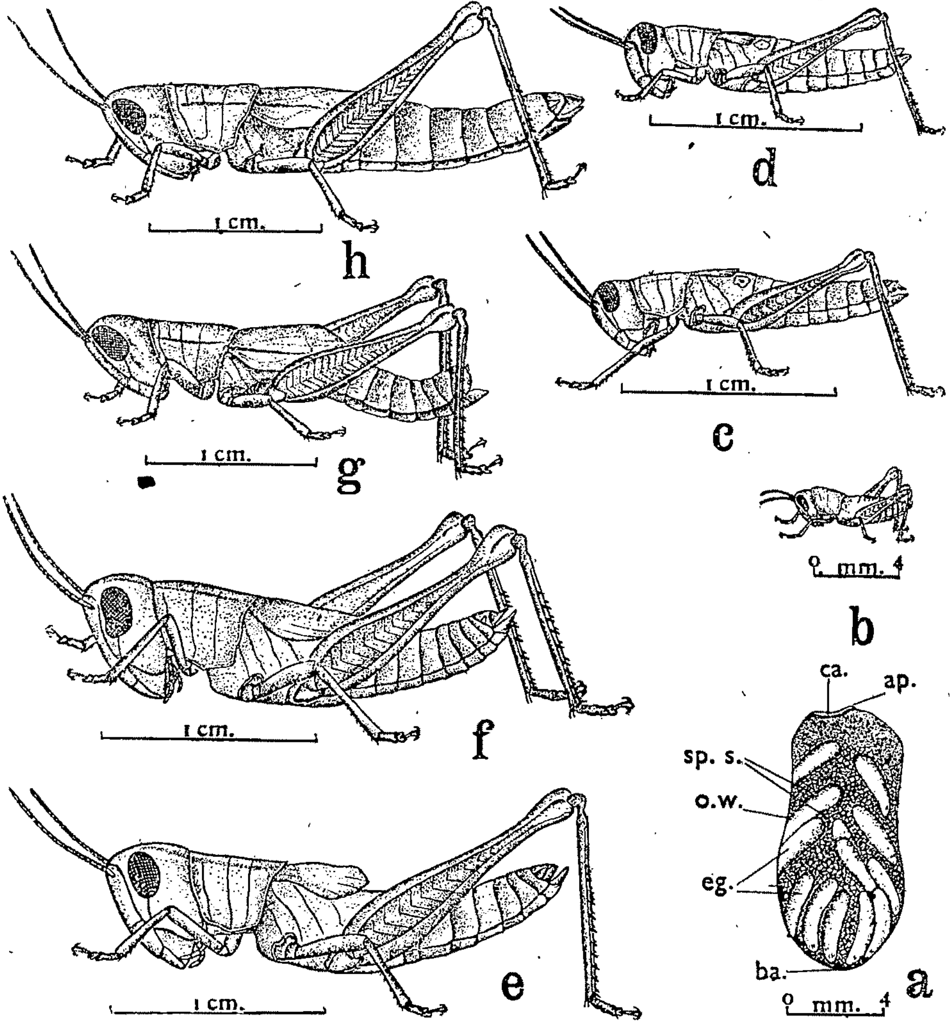
This upturning or directional-reversal in the orientation of the *elytron-wing complex*, takes place after the fourth moult, *i. e.*, in the fifth chronological instar, which confirms the Rule 2 of Roonwal (1946; 1952).

Sixth stage: (figs. *e*, *f*.).

General colour: Body pinkish, wings greenish. Two lateral bands in head; one lateral longitudinal black line from thorax continuing up to wings; and two streaks on the hind-legs become very definite, though dots on femur inbetween streaks more or less vanish. Wings and genitalia in both sexes develop further, and extent more backwards. Cerci in males three lobed; in females simple and short. Average length of males 21. 35 mm.; females 29. 1 mm.

Seventh stage (*Adult*): (figs. *g*, *h*.)

General colour: Body yellowish-pink; wings greenish. Scutellum of vertex short; pronotum closely punctured, with four sulci, one lateral. From upper extremity of pronotum starts a thick blackish line backwards upto the end of the elytron; one thick line on each raised area above the joint of middle- and hind-legs. *Head*:—yellowish pink, with a longitudinal band from lower margin of eyes to pronotum. *Legs*: Two anterior pairs yellowish pink, with a blackish line on outer side of tibia of middle-legs. Streaks on hind-femur vanish except in few cases of females (where only lower one occurs). Tibia of hind-legs usually bluish (with the same number of spines as in the 1st stage). A black spot at end of femur before the extremity. Tegmina exten-



Parahieroglyphus bilineatus Bolivar (*a*) Egg-pod showing arrangement of eggs just below the outer wall. (*b*) First stage hopper. (*c*) Fourth stage female hopper. (*d*) Fourth stage male hopper. (*e*) Sixth stage male hopper. (*f*) Sixth stage female hopper. (*g*) Adult male. (*h*) Adult female.

Lettering: *ap*., apex of egg-pod; *ba*., base of egg-pod; *ca*., hard cap of egg-pod; *eg*., egg.; *o.w*., outer wall of egg-pod; *sp. s*., hard spongy secretion.

ding beyond the caudal margin of 3rd abdominal segment (in few cases in males even beyond 4th abdominal segment). Male genital plate obtusely conical, not longer than its basal width; with large, hard trilobed cerci. Females genital plate with apex divided into three lobes. Average length of males, 24. 8 mm.; females, 35.9 mm.

(*b*) *Key to the instars*

The following key is applicable to the normal development when six moults occur. The directional-reversal of the elytron-wing complex takes place after 4th moult, *i. e.*, in the fifth chronological instar as described above. The two stages, after directional-reversal of the wings (*i. e.*, fifth and sixth stages), do not differ much except in size. The last or adult stage is conspicuously different from the one immediately preceding it.

1 (12) Tegmina and wings wanting or rudimentary ... ... *Nymph*
2 (9) Wing-pads *point ventrad*, antenna with 13 to 22-24 segments, rows of black dots on hind-femur.
3 (6) Wing-pads wanting, antennae 13-14 segmented.
4 (5) Wing-pads indistinct; antennae 13-segmented ... ... *1st stage*
5 (4) Wing-pads small but distinct; antennae 14-segmented. ... ... *2nd stage*
6 (3) Wing-pads well developed; two outer streaks on hind-legs weakly to distinctly indicated; antennae 17-21 to 22-24-segmented.
7 (8) Wing-pads and both upper and lower longitudinal streaks blackish on hind-femora; weakly indicated; antennae in males 17-19, in females 17-21—segmented ... ... *3rd stage*
8 (7) Wing-pads and streaks on hind-femora distinctly indicated; antennae in males 22-24 in females 23-24—segmented. ... ... *4th stage*
9 (2) Wing-pads *point dorsad* (*upturned*).
10 (11) Elytron short, extending to or slightly beyond the caudal margin of metathorax; antennae in males 22-23, and in females 24-26—segmented. ... ... *5th stage*
11 (10) Wing-pads extending beyond the caudal margin of 1st abdominal segment; antennae in males 24-26 and in females 24-27—segmented. ... ... *6th stage*
12 (1) Elytra (micropterous type) and wings fully developed but of the small or micropterous type; with a black line in elytron in continuation of that on pro-notum; antennae in males 24-27, in females 26-29 segmented. ... ... *7th stage* (*Adult*)

V. FOOD-PLANTS

Both nymphs and adults feed on green foliage. They prefer leaves of maize, (*Zea mays*;), and various types of grasses. They were also often noticed cutting and eating tender portion of paddy.

In the Insectary cages, the grasshoppers were given the common green grasses. They also liked leaves of pumpkin (*Lagenaria vulgaris*; family, Cucurbitaceae) and beet (*Beta vulgaris;* family, Chenopodiaceae). Nymphs and adults also readily ate moist bran.

TABLE I. Mating records in *Parahieroglyphus bilineatus* Bolivar during the years 1951-52 in Dehra Dun.

Dates	Number of mating pairs (1951)		Dates	Number of mating pairs (1952)		Remarks
	In Insectary	In field		In Insectary	In field	
8. 9. 51	1	—	28. 8. 52	—	1	Mostly 1st to 3rd weeks of September in Insectary (in breeding cages); 3rd and 4th weeks of September in field (natural conditions.)
11. 9. 51	3	—	4. 9 52	—	1	
16. 9. 51	7	3	5. 9. 52	—	2	
21. 9. 51	11	2	9. 9. 52	2	2	
25. 9. 51	2	—	15. 9. 52	6	1	
30. 9. 51	1	2	16. 9. 52	9	4	
			20. 9. 52	12	3	
			21. 9. 52	9	5	
			23. 9. 52	8	17	
			25. 9 52	5	11	
			26. 9 52	4	19	
			27. 9. 52	1	8	
			28. 9. 52	1	14	
			29. 9. 52	2	7	
			4. 10. 52	—	4	
			5. 10. 52	—	2	
			6. 10. 52	—	1	
			8. 10. 52	—		

TABLE II. Egg-laying record of *Parahieroglyphus bilineatus* Bolivar during the years 1951 to 1953, in Dehra Dun.

Dates	Number of females ovipositing (1951)		Dates	Number of females ovipositing (1952)		Dates	Number of females ovipositing (1953)		Remarks
	In Insectary	In field		In Insectary	In field		In Insectary	In field	
12. 9. 51	2	—	10. 9. 52	1	—	18. 9. 53	3	1	Maximum number during 2nd and 3rd weeks of September in Insectary; and from 20th Septemer to October 4th, in field.
14. 9. 51	2	—	14. 9. 52	1	—	19. 9. 53	2	—	
15. 9. 51	4	—	15. 9. 52	1	—	21. 9. 53	4	1	
16. 9. 51	1	—	18. 9. 52	4	—	25. 9. 53	7	3	
18. 9. 51	1	1	19. 9. 52	6	—	26. 9. 53	4	5	
21. 9. 51	5	2	20. 9. 52	3	3	27. 9. 53	—	11	
22. 9. 51	9	3	22. 9. 52	4	7	30. 9. 53	—	4	
23. 9. 51	4	4	4. 10. 52	1	9	2. 10. 53	1	5	
26. 9. 51	3	5	8. 10. 52	—	5	5. 10. 53	—	4	
29. 9. 51	—	2	11. 10. 52	—	3	6. 10. 53	—	2	
1. 10. 51	—	8	12. 10. 52	1	—	9. 10. 53	—	1	
3. 10. 51	—	7	14. 10. 52	1	1	10. 10. 53	1	1	
6. 10. 51	—	3	18. 10. 52	—	1	15. 10. 53	—	2	
7. 10. 51	1	—				21. 10. 53	—	2	
8. 10. 51	1	2				22. 10. 53	—	1	
12. 10. 51	—	1				26. 10. 53	—	1	
15. 10. 51	—	1							
21. 10. 51	—	2							
25. 10. 51	—	1							
28. 10. 51	—	1							

TABLE III. Period taken by *Parahieroglyphus bilineatus* Bolivar for its development from 1st stage hopper to adult in the year 1952.

Abbreviation :—I, nymphs isolated in tubes; G, nymphs in general cage.

Date of hatching	1st stage		2nd stage		3rd stage		4th stage		5th stage		6th stage		7th stage	Total Period
	Dates	Period	Dates	Period	Dates	Period	Dates	Period	Dates	Period	Dates	Period		
6th to 8th June 1952. (G)	6-8.6.52 to 17-19.6.52	11-13 Days	17-19.6.52 to 27-30.6.52	11-14 Days	27-30.6.52 to 10-15.7.52	14-19 Days	10-15.7.52 to 22-27.7.52	12-17 Days	22-27.7.52 to 6-11.8.52	14-18 Days	6-11.8.52 to 23.8.52-4.9.52	17-23 Days	23.8.52-4.9.52	78-88 Days
6th June 1952. (4 males, I)	6.6.52 to 17.6.52	11 Days	17.6.52 to 27.6.52	10 Days	27.6.52 10.7.52	14 Days	10.7.52 to 22-24.7.52	12-14 Days	22-24.7.52 to 6-7.8.52	14-15 Days	6-7.8.52 to 23-25.8.52	17-18 Days	23.8.53 (3) 25.8.53 (1)	78 days (3 males) 80 days (1 male)
6th June, 1952. (2 females, I)	6.6.52 to 17.6.52	11 Days	17.6.52 to 28.6.52	11 Days	28.6.52 to 13.7.52	15 Days	13.7.52 to 24-25.7.52	11-12 Days	24-25.7.52 to 9-10.8.52	16 Days	9-10.8.52 to 28-30.8.52	19-20 Days	28.8.52 & 30.8.52	83 days & 85 days
8th June, 1952. (I) female	8.6.52 to 21.6.52	13 Days	21.6.52 to 2.7.52	11 Days	2.7.52 to 14.7.52	12 Days	14.7.52 to 26.7.52	12 Days	26.7.52 to 11.8.52	16 Days	11.8.52 to 30.8.52	19 Days	30.8.52	83 days
8th June, 1952. (I) female	8.6.52 to 21.6.52	13 Days	21.6.52 to 4.7.52	13 Days	4.7.52 to 20.7.52	16 Days	20.7.52 to 2.8.52	12 Days	2.8.52 to 18.8.52	16 Days	18.8.52 to 4.9.52	17 Days	4.9.52	87 days

TABLE IV. Summary of life-cycle data of 5 pairs (Male & Female) of individuals of *Parahieroglyphus bilineatus* Bolivar in Insectary at New Forest, Dehra Dun.

Pairs, (and year)	Sex	Length of period					Number of egg-pods laid	Number of eggs in consecutive egg-pods.
		Hatching to eclosion (days)	Eclosion to copulation (days)	Copulation to oviposition (days)	Eclosion to death (days).	Total (days).		
A (in 1951)	Male	—	7	—	43	—	1	40, 38, 32, 32 and 30.
	Female	—	10	10	60	—	5	
B (in 1951)	Male	80	7	—	32	112	9	38, 37, 36, 35 and 28.
	Female	88	12	10	55	143	5	
A (in 1952)	Male	78	6	—	34	112		38, 35, 34 and 32.
	Female	88	12	14	60	148	4	
B (in 1952)	Male	73	8	—	37	115		39, 34 and 33.
	Female	83	15	7	58	141	3	
C (in 1952)	Male	80	8	—	33	113		38, 36 and 33.
	Female	87	14	12	64	151	3	
Range of male		78-80	6-8	—	32-43	112-121	—	Av. of 1st egg-laying 38.6 eggs „ „ 2nd „ 36.0 „ „ „ 3rd „ 34.0 „ „ „ 4th „ 33.0 „ „ „ 5th „ 29.0 „
Average of male		78.8	7.2	—	35.8	114.6	—	
Range of female		83-88	10-15	9-12	55-64	141-151	3-5	
Average of female		86.6	12.6	10.4	59.4	144.2	4	

VI. SEASONAL LIFE-HISTORY IN DEHRA DUN

The following brief account will give a rough idea of the seasonal life-cycle of *Parahieroglyphus bilineatus* in Dehra Dun.

In field	*In Insectary*
1. *Copulation* (Table 1). From August 28th to October 8th (nearly 40-42 days); mostly in 3rd and 4th weeks of September.	1. *Copulation* (Table 1). From 1st week of September to 1st week of October (nearly 28 days); mostly in the 1st to 3rd week of September.
2. *Oviposition* (Table 2). From September 18th to October 28th (about 40 days); maximum from September 20th to October 4th.	2. *Oviposition* (Table 2). From September 12th to October 8th, in 1951; from September 10th to October 14th, in 1952; from September 18th to October 10th, in 1953; maximum during the 2nd and 3rd weeks of September.
3. *Hatching* From last week of May to last week of June; maximum during 2nd week of June in 1951, and 1st week of June in 1952.	3. *Hatching* From 30th May to 4th July, thus; From June 6th to July 1st in 1952; From June 9th to July 4th in 1953; From May 30th to July 2nd in 1954. Peak hatching in the 1st and 2nd weeks of June.
4. *Hopper stages* (Table 3) Available in the field:— I stage: 12. vi. 52 to 26.vi. 52, (16 days). II stage: 22. vi. 52 to 12. vii. 52, (20 days). III stage: 8. vii. 52 to 23. vii. 52, (15 days). IV stage: 15. vii. 52 to 12. viii. 52. (27 days.) V stage: 26.vii. 52 to 25. viii. 52, (29 days) VI stage: 18. viii. 52 to 10. ix. 52.(22 days) VII stage: 7. ix. 52 to 24. x. 52, (47 days)	4. *Hopper stages* (Table 3). From the breeding records in Insectary I stage: 6-8. vi. 52 to 17-19. vi. 52, (11-13 days). II stage: 17-19. vi. 52 to 27-30. vi. 52, (10-14 days). III stage: 27-30 vi. 52 to 10-15. vii.52, (14-19 days). IV stage: 10-15. vii. 52 to 22-27 vii. 52 (12-17 days.) V stage: 22-27. vii. 52 to 6-11. viii. 52, (14-18 days). VI stage: 6-11. viii. 52 to 23. viii. 52-4. ix. 52, (17-23 days). VII stage: By September 4th almost all become adults.
5. *Adult stage* (Table 4) Males survived upto 1st and sometimes up to 2nd week of October. Females survived up to October 14th in 1952; and a few only upto October 18th in 1953.	5. *Adult stage* (Table 4) Males usually die off by 1st week of October. Females survived upto 3rd week of October in 1952; two females lived upto November 9th in 1953.

VII. NATURAL ENEMIES

Due to its pinkish-yellow body and greenish wings, *Parahieroglyphus bilineatus* escapes detection in greenish-yellow grasses as well as in paddy and maize fields. A few birds, *viz*, the *koel* (*Eudynamis scolopaceus* Linnaeus) (family Eudynaminae), and *nilkant* or *sabzak* (Hindi) (Roller or Blue Jay, *Coracias benghalensis* Linnaeus, family Coraciidae), were seen feeding on the nymphs as well as the adult grasshoppers. In the Insectary, nymphs and adults were sometimes attacked by ants and by the house lizard.

The author also tried adult *Parahieroglyphus bilineatus* as a bait for fishes, and found that fishes preferred them to earthworms.

Some suggestions for control.—Although control measures were not studied, a few points which may be of use in control are worth mentioning. The outer layer of the egg-pod is thick and is so compact and cemented that heat and water do not effect the eggs inside the pod easily. Egg-pods which were kept in the sun for more than 2 months hatched successfully. Similarly, ploughing the fields (during which operation the egg-pods were exposed to the sun) did not reduce the population materially. Nor was the population effected when the fields were flooded due to the heavy rains in 1953. Eggs from egg-pods which were kept submerged in water for 10-12 days also hatched as usual.

The general tendency among females is to lay eggs along the sides of trodden paths, *e. g.*, the cart-route, high base of the paths and margins of the paddy fields, and so on. It is therefore easy to detect the location of egg-pods for control purposes.

VIII. SUMMARY

1. *Parahieroglyphus bilineatus* Bolivar is very common in and near paddy and maize fields and near high grass-lands in the forests around Dehra Dun. It feeds on green grasses, paddy, maize, beet, and pumpkin leaves. Nymphs and adults are not gregarious.

2. Mating takes place from 1st week of September up to about the 1st week of October. Eggs are laid from September to October and hatch after 7-9 months (in the last week of May to late June or early July of the following year). The life-cycle is thus annual, there being one generation per year.

3. Six-moults occur, the adult being the 7th stage.

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MORPHOLOGICAL AND EMBRYOLOGICAL STUDIES IN SOME SANTALACEAE*

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Among the Angiospermous parasites, Santalaceae, Loranthaceae, and Balanophoraceae are most difficult for embryological investigations (Maheshwari, 1937). They present a number of unusual features, some of which at least are correlated with their parasitic mode of life (Singh, 1952). Smith and Smith (1942 b) also believe that the variations and the pronounced reduction in vascular supply of the inferior ovary in different genera of Santalaceae are mainly due to the parasitic nature of these plants. Rao (1942), however, believes that the unusual features of Santalacae have nothing to do with their parasitic or semi-parasitic nature.

Santalaceae present a number of interesting morphological problems, of which the nature of the inferior ovary, the placenta and the place of origin of the female gametophyte are most important. A review of the previous work would reveal considerable differences of opinion with regard to these problems. The developmental studies of the embryo sac, endosperm and embryo in this family are also only fragmentary.

This paper deals with investigations on *Osyris arborea* Wall.; *Santalum album* L.; *S. yasi* Seemann; *Thesium alpinum* L.; *T. humifusum* D. C. and *T. rostratum* Mert & Koch.

Review of Previous Work

The floral anatomy of Santalaceae has been studied by a number of workers (Van Tieghem, 1869 b; Dowding, 1931; Schaeppi and Steindl, 1937; Rao, 1942; Schaeppi, 1942; Smith and Smith, 1942 a, b) and the inferior ovary has been variously interpreted as appendicular or receptacular. Its mamelon has been compared with the free-central placenta of Primulaceae (Engler and Prantl, 1935; Schaeppi and Steindl, 1937; Schaeppi, 1942; Wilson and Just, 1939). Johnson (1889) and Rao (1942) have considered this mamelon as cauline, while Van Tieghem (1869 a) and Smith and Smith (1942 a, b) mention that it consists entirely of carpellary tissue. Schaeppi and Steindl (1937) and Schaeppi (1942) from their studies on *Osyris* and *Thesium* have suggested that the central placenta though mainly carpellary in the peripheral part has a central core of axial tissue.

The investigations on microsporogenesis and the development of male gametophyte made in *Osyris* (Schaeppi and Steindl, 1937; Rao, 1942), *Santalum* (Iyengar, 1937; Rao, 1942) and *Thesium* (Schulle, 1933; Rutishauser, 1937) are only of a fragmentary nature and the details are lacking.

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*Based on thesis submitted for the Ph. D. degree of the University of Agra (1954).

The embryological investigations attracted the attention of some of the pioneeer workers early in the 19th century on account of the unusual anterior as well as posterior elongation of the embryo sac in the ovary cavity and the placenta respectively, first reported by Griffith in 1844. He interpreted the former feature as a phenomenon facilitating the fertilization by pushing the egg apparatus towards the stigma in vicinity of the pollen tube. Several workers (Henfrey, 1856; Schacht, 1850, 66; Jönsson, 1879/80; Guignard, 1885; Strasburger, 1877, 78, 85) confirmed Griffith's findings in *Santalum* and other plants of this family.

Modilewski (1928), Schulle (1933) and Rutishauser (1937) have recently described some developmental stages in different species of *Thesium*. Iyengar (1937) in *Santalum*, Schaeppi and Steindl (1937) in *Osyris* and Rao (1942) in *Osyris*, *Santalum*, *Scleropyrum* and *Thesium* tried to study the development of the embryo sac, endosperm and embryo. Their remarks are also fragmentary. Very recently Fagerlind (1948) has carried out a comparative study of the members of Santalales and has devoted some attention to the morphology and embryo sac of *Santalum pyrylarium*. While pointing out the difficulties experienced in the embryological investigations of this family the author (Paliwal, 1953) has suggested the use of micro-dissections of the whole structures to solve these problems.

MATERIAL AND METHODS

The flowers and fruits of *Santalum album* were fixed in formalin-acetic-alcohol and also Nawaschin's killing fluid from Taj gardens, Agra, and *S. yasi* from Bangalore. Material of *Osyris arborea* was partly collected by me from Nandi Hills, Bangalore, and partly received from the Curator, Government Gardens, Ootacamund, and Mr. B. K. Sharma from Dehra Dun. The alcoholic material of *Thesium humifusum* from Cambridge, *T. alpinum* and *T. rostratum* from Switzerland were received through Prof. B. Singh. Recently Mr. E. J. H. Corner kindly sent me some preserved material of *T. humifusum* from Cambridge.

A part of the material was dehydrated through tertiary butyl alcohol series and embedded in paraffin. The rest was used for the microdissections of embryo sacs, endosperm and embryo (see Paliwal, 1953). The account of embryo sac, endosperm and embryo presented here is based on the study of whole mounts of excised structures as well as serial microtome sections. The sections, cut 6 to 15 μ thick, were stained with Heidenhains-iron-alum-haematoxylin, acetocarmin, safranin-fast green and crystal violet-erythrosin combinations. Belling's-iron-acetocarmin (Belling, 1926; Johansen, 1940) was found to be fairly satisfactory for embryological studies as the non-protoplasmic contents remained mostly unstained and did not hinder in observations. The slides were graded down to water and stained with 1% acetocarmin solution for 30 minutes to an hour. The overstained sections were differentiated with 2% aqueous chloral hydrate or 10 to 15% acetic acid put in 50%

alcohol grade. Safranin-fast green stain was considerably improved when the slides were kept in 1% chromic acid solution before staining. For the study of the male gametophyte anthers were smeared in acetocarmin and made permanent by the McClintock method (McClintock, 1929; Johansen, 1940). The study of the development of the fibrous thickenings in the endothecial cells was very much facilitated in whole mounts. The anthers, treated according to the whole mount technique (Paliwal, 1953), were stained with basic fuchsin and differentiated with 5% acetic acid. The thickened plates were stained red and stood in clear contrast against unstained cell walls.

OBSERVATIONS

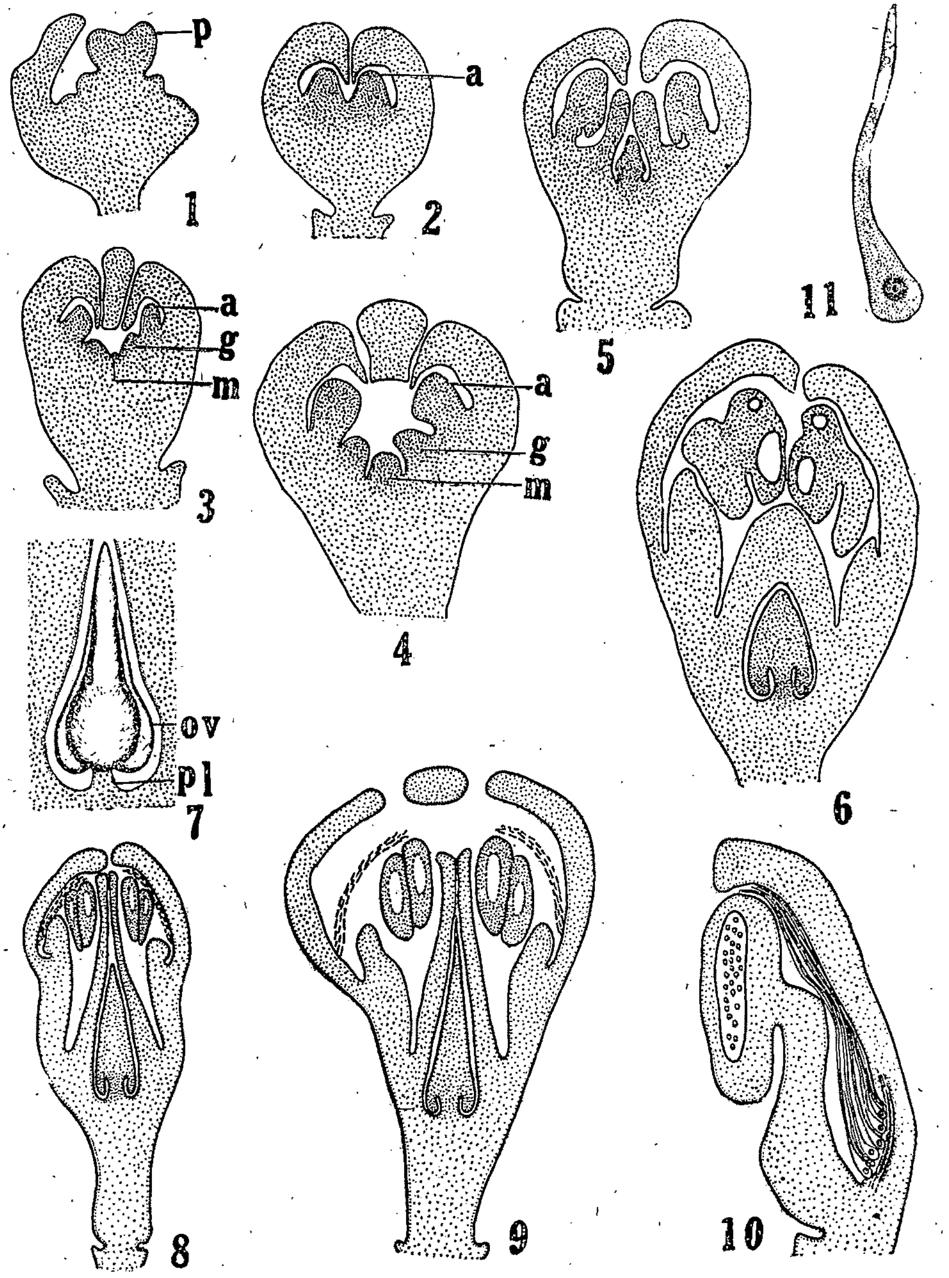
Santalum Spp.

Organogeny of the flower.—The order of development of the floral parts in both species *S. album* and *S. yasi* is in the regular sequence. The perianth primordia are differentiated first (Fig. 1, *p*), followed by those of androecium (Fig. 2, *a*). The perianth lobes soon close up at the top, their tips become involuted and protrude in the space between the anther primordia. The gynaeceum arises as a lateral fringe projecting from the concave surface of the receptacle (Fig. 3, *g*). The mamelon primordium can also be made out simultaneously at the base (Figs. 3, 4, *m*). Schulle (1933) and Rutishauser (1937) have also mentioned the simultaneous origin of the placenta with the carpel wall primordia in *Thesium* spp.

The carpel primordia soon close up and form the ovary cavity (Figs. 5, 6), enclosing the mamelon, which has three ovules originating laterally near the tip of the short free central placenta. The latter shows some meristematic activity at its base which gives rise to the placental stalk, elevating the ovules (Figs. 6—9).

Soon after the ovule primordia are established, active periclinal divisions ensue in them, followed by more vigorous anticlinal divisions in the cells on the outer side of the young ovule. They are, therefore, curved downwards and become pendulous, with their tips reaching near the base of the ovary cavity. The chalazal part of the ovule, that is directed up in the flower, also starts growing in union with the placenta to form the elongated beak of the mamelon (Figs. 6—9). At maturity the mamelon acquires a conical shape (Fig. 7) whose three lobes represent the free part of the three ovules, with the beak of the mamelon extending up to the stylar canal (Figs. 8, 9).

Morphology of the flower.—The flowers are hermaphrodite and are borne in threes on a racemose inflorescence. They are usually tetramerous, only rarely pentamerous flowers may also be met with. The bud is whitish green in colour, with its perianth lobes joined to form an obtuse tip. As the flower opens the tips of the perianth lobes are reflexed at right angles. These reflexed tips, as well as the lobes of the alternate and epiphyllous disc, turn deep brown



TEXT FIGS. 1—11, Showing the organogeny of the flower and its morphology; (Figs. 1—8 & 10, *S. album*; 9 & 11, *S. yasi*). (*a*, androecium; *g*, gynaeceum; *m*, mamelon; *ov*, ovule; *p*, perianth; *pl*, placenta).

FIGS. 1—6, l. s. flower buds of different stages. Fig. 7, diagrammatic perspective view of the mamelon. Figs. 8 & 9, l. s. flowers. Fig. 10, l. s. of a perianth lobe and/its epiphyllous stamen to show glandular hairs. Fig. 11, a glandular hair more magnified.
Figs. 1, 5, 6, 10, × 33; figs. 2-4, × 70; figs. 8, 9, × 15; fig. 11 × 150.

in colour. Stamens are as many as the perianth lobes, epiphyllous and have a broad dorsifixed filament, with a thick connective. Long glandular, unicellular hairs are borne on the inner surface of the perianth near the foot of the filament (Figs. 8—10). One prominent nucleus is present at the considerably swollen base of each hair (Figs. 10, 11). These hairs grow up along the filament and cover the top of the anther completely by the time the flower opens. Some lustrous fluid is discharged from these hairs in *S. album*, which probably appears to have some role in the germination of the pollen grains *in situ*, as is discussed later on.

The ovary is apparantly seminferior and unilocular. Cross sections at the base of the ovary cavity in older flowers present three depressions in the form of locules. These are formed in later stages of development of the flower when the embryo sacs come out of the ovules and crush the cells at the base of the ovary to form small depressions in which the tips of the ovules and the embryo sacs rest. Smith & Smith(1942b) have also mentioned the presence of these depressions in the base of the ovary where the ovules rest in *S. freycinetianum*. They are, however, silent about the method of their origin. A study of cross sections of the ovary in the region of these depressions has led Rao (1942) to conclude that in *S. album* the ovary is trilocular below and unilocular above.

As already mentioned the beak of the mamelon becomes much elongated so that its tip is extended up to the stylar canal (Figs. 8, 9). Regarding this mamelon Rao (1942) writes that "The placenta rapidly enlarges as the result of basal and intercalary growth, so that it fills the small cavity of the ovary and becomes compressed and contorted in adjusting itself to the limited space available." This is, however, not so in the material of *S. album* studied by the present author. Fagerlind (1948), who has called the mamelon as "Zentral Plazenta - Samenanlagen - Komplex" or "Zentralsaüle - Samenanlagen - Komplex," writes about this structure in *S. pyrylarium*, "Ein Längsschnitt durch die letztere zeigt eine langgesheckt herzformige Bildung, deren Spitze sich hoch hinauf in den Griffelkanal erstreckt."

In *Osyris*, *Thesium* and most other genera of Santalaceae the mamelon does not grow up much beyond the level of the ovule attachment and, therefore, has no beak. This elongated beak, which is a characteristic feature of *Santalum*, has been considered by Rao (1942) and Smith and Smith (1942 b) to be entirely the prolongation of the placenta above the level of ovule attachment. Rao (1942) has, therefore, concluded that in *Santalum* the ovules are borne on the basal part of the placenta.

A closer study of the histology of the beak shows that its peripheral part possesses the same type of tissue as is found in the chalazal part of ovule, while the central tissue of the beak is slightly different. It is, therfore, formed by the growth of the fused bases of the ovules in the upward direction along with the placental tissue in the centre.

The style is long, trifid and has a narrow stylar canal (Figs. 8, 9). In

S. album as the flower opens the upper half of the style turns pink, while the lower half remains whitish. An inconspicuous ring is formed at the junction of two colours. The anthesis studies reveal that the upper, coloured, part of the style is shed earlier, while the lower half falls off later on. *Dendrophthoe falcata*, a parasitic plant of Loranthaceae, seems to be a case of similar type reported in literature (Singh, 1952).

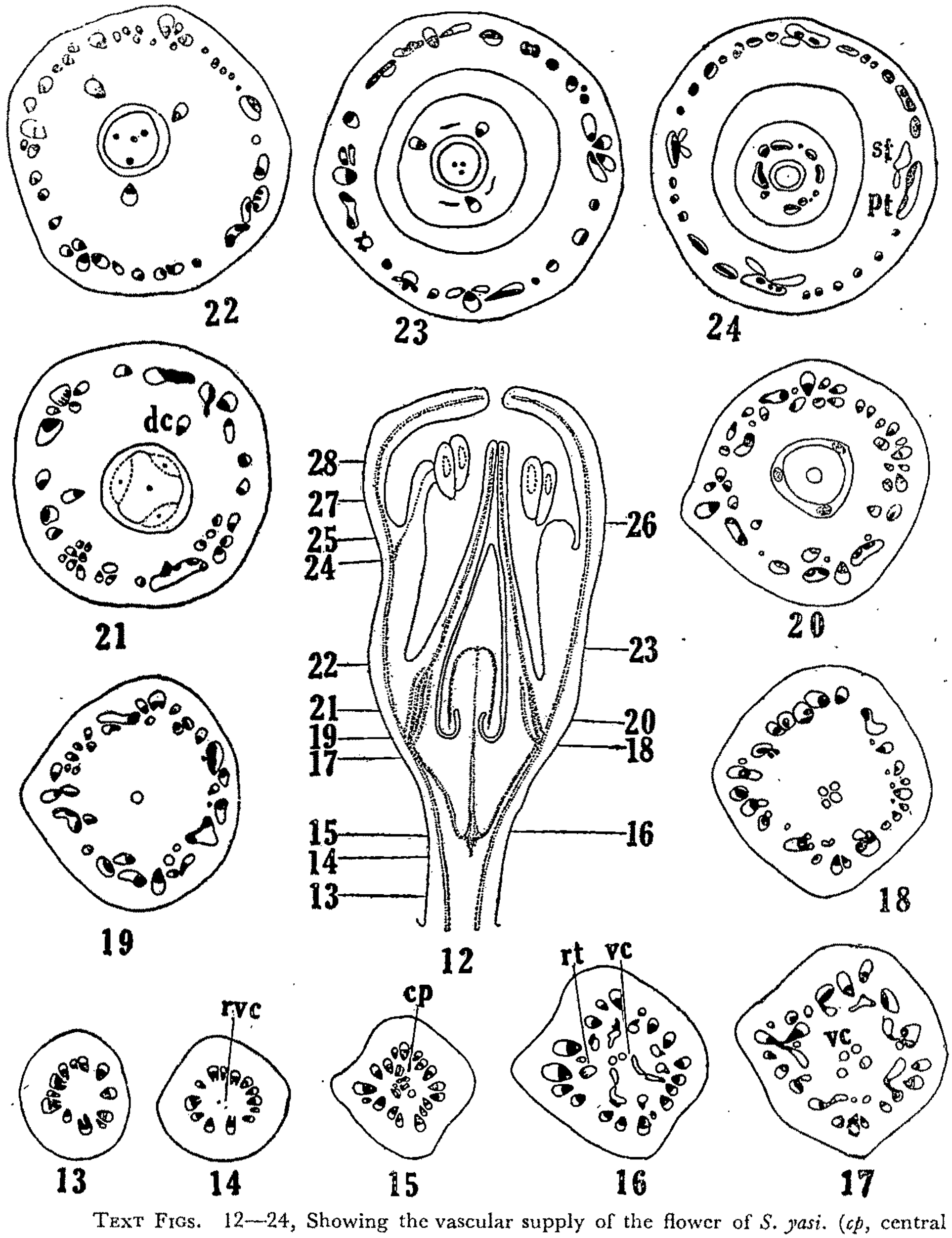
Vascular supply of the flower.—The diagrammatic figure 12 shows the longitudinal course of the vascular supply in the flower of *S. yasi*. The index numbers give the levels at which the transverse sections have been taken. A few collateral vascular strands, compactly arranged round a small pith, enter the receptacle, where they divide to form several strands (Fig. 13). These ascend obliquely upward, forming the main vascular supply of the flower. Its strands go up undisturbed nearly to the level of the base of the ovary cavity (Fig. 12, level 18). Here a number of recurrent branches arise which bend down and travel obliquely to reach the base of the flower (Fig. 12). The recurrent traces on account of their downward course have their xylem inversely oriented (Figs. 12, 16 *rt*, 17). They anastomose with each other lower down in the flower to form a central plate of vascular tissue in the pith region (Fig. 15 *cp*). A few branches arise from this plate and travel upward and inward for some distance (Figs. 12, 16, 17 *vc*, 18). These finally fuse with each other to form a compound strand (Figs. 12, 19) which is mainly procambial in nature. This procambial strand enters the placenta as ventral carpellary supply (Figs. 12, 20). A few branches from the central plate continue downward course for some distance and then end blindly in the lower part of the flower (Fig. 12). When transverse sections are studied from base upward, this tissue appears suddenly in the pith region near the base of the flower (Fig. 14 *rvc*).

The ventral carpellary supply travels upward for some distance in the mamelon (Figs. 12, 20-22) and then sends branches one to each of the three ovules (Figs. 21, 22). The ventral carpellary supply remains procambial for long and the differentiation of xylem elements takes place in later stages basipetally from the ovule to the placenta. Rao's (1942) statement that in *S. album* the central placenta does not receive any vascular supply from the main ring seems to be due to its prolonged procambial nature.

The main ring of vascular supply continues up after giving off the recurrent traces. Soon a number of traces are given out from this ring which ascend obliquely inward and are normally oriented (Figs. 12, 20-22). Three of these which are more prominent represent the dorsal carpellary traces (Figs. 21 *dc*, 22). The smaller traces go up for some distance and some of them may fuse with the dorsal carpellary traces while others disappear blindly. These have been called 'X Traces' by Smith and Smith (1942 a, b).

At level 23 anastomoses appear between the adjacent dorsal carpellary strands (Fig. 23), which divide to form ten to twelve small bundles

(Fig. 24). Most of these gradually disappear in their upward course (Figs. 25, 26), leaving ultimately only three vascular bundles in the style. In

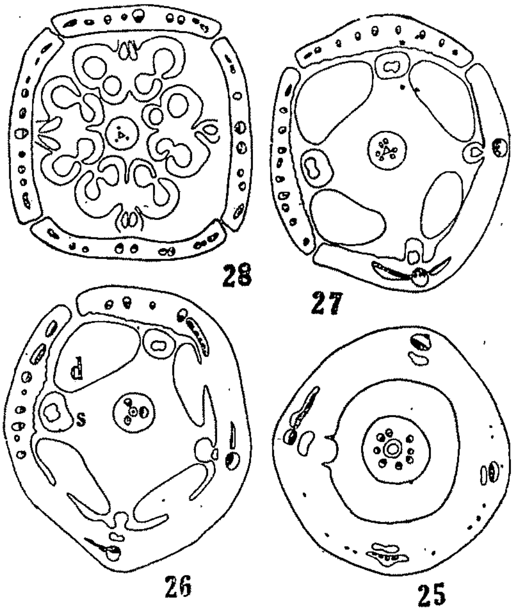


TEXT FIGS. 12—24, Showing the vascular supply of the flower of *S. yasi*. (*cp*, central plate of vascular tissue; *dc*, dorsal carpellary supply; *pt*, perianth traces; *rt*, recurrent traces; *rvc*, residue of the ventral carpellary supply; *st*, staminal traces; *vc* ventral carpellary supply).
Fig. 12, diagram showing the longitudinal course of the vascular supply.
Figs. 13—24, t. s. flowers at levels marked in the index. Fig. 12. Explanation in the text.
Fig. 12, × 40; figs. 13-24, × 25.

the upper part of the style, these bundles divide once again into six (Fig. 27), but their number is soon restored to three with one bundle situated at each of the angles of the triradiate stylar canal (Fig. 28). In the stigmatic region these bundles get deflected into each of the three separate stigmatic flaps to terminate at the tip of each stigmatic lobe.

After giving off the dorsal carpellary supply the main ring differentiates into separate groups of vascular bundles. Four groups of bundles retain their normal orientation, where as those between them take a swing and become inverted (Figs. 21-24). The normally oriented vascular bundles of each group draw nearer each other and some of them fuse together. Thus four large strands, each having large amount of phloem investing some groups of xylem are formed in the perianth positions (Figs. 24 *pt*, 25). The inverted bundles between them also anastomose with adjacent bundles. Two such inverted bundles, present one on each side of the large strand, take an inward swing and come to lie below and opposite to it (Figs. 24 *st*, 25). These inswinging bundles fuse with each other, and represent the staminal traces (Figs. 24-27). Some inverted traces that are left between perianth positions continue for some height but are considerably weakened, and ultimately disappear always before the level at which the stamens are separated from the perianth tube (Figs. 25, 26).

Each compound staminal bundle, which is now represented as a phloem strand only, enters the filament when the latter is freed from the perianth



Text Figs. 25—28, Showing the vascular supply of the flower of *S. yasi*. (*d*, disc; *s*, stamen). Figs. 25—28, t. s. flowers at levels marked in the index figure 12. Explanation in the text. × 18.

(Figs. 26, 27). This strand, which consists of two loosely joined bundles, remains so throughout the length of the filament. In the connective region the two bundles separate to supply each anther lobe (Fig. 28).

Each bundle in the perianth position divides into three, one median and two laterals. These divide again to form nine to ten bundles in each perianth lobe (Figs. 26-28). No vascular bundles enter the disc.

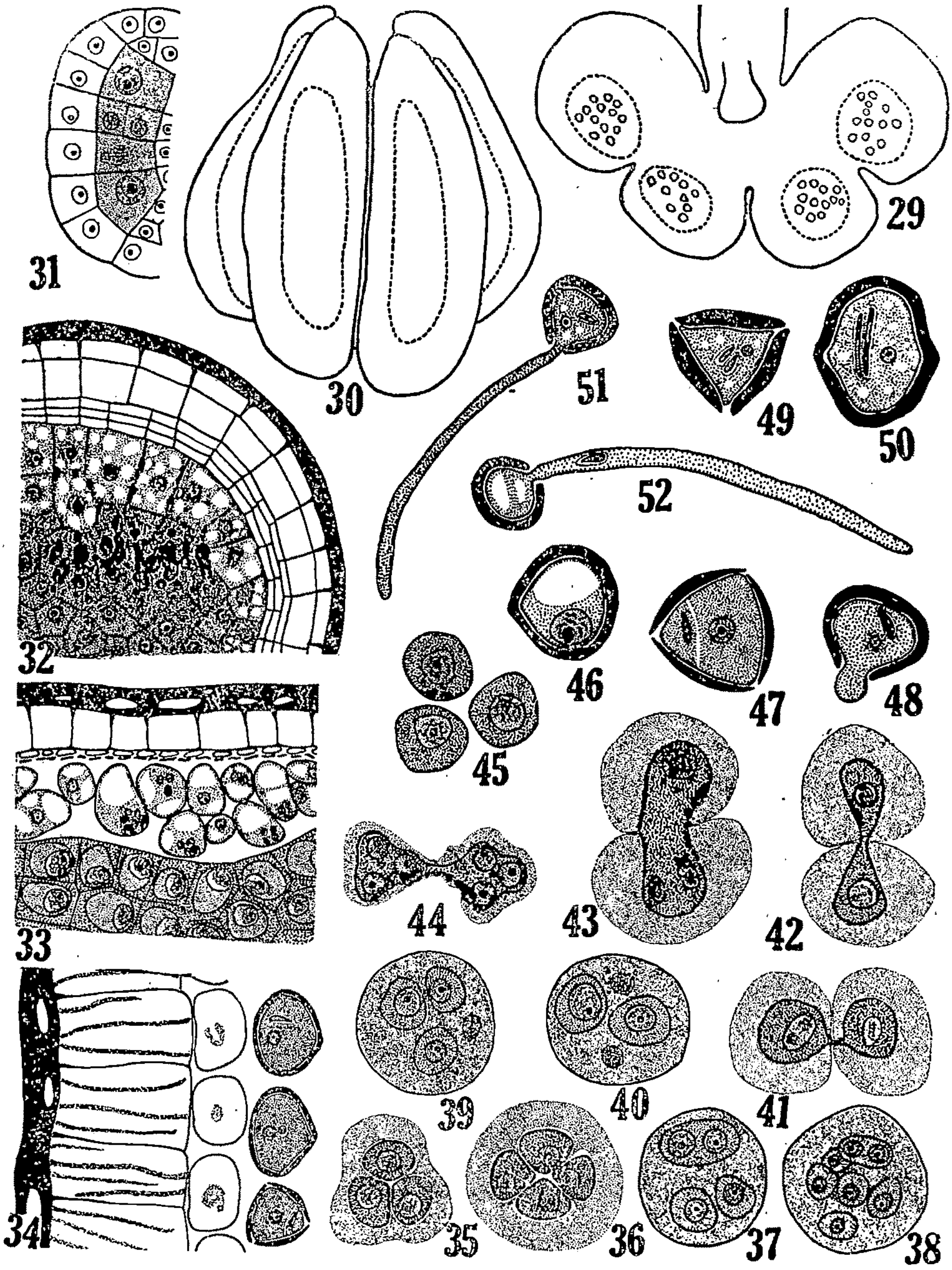
The floral anatomy of *Santalum* has also been studied by Rao (1942) and Smith and Smith (1942 b). Rao has made only fragmentary remarks about the vascular supply, but Smiths have given a fairly detailed account. They report that the dorsal carpellary traces are absent from the base of the ovary to the level at which the 'X' traces appear in *S. freycinetianum*, and are well developed above it. They further report that inversely oriented branches arise from sepal traces and are directed downward. From this they conclude that the floral tube is also receptacular for a considerable length. Smiths' interpretations of the vascular supply of Santalaceous flowers are not above doubt and have been discussed at length later.

Anther.—The dorsifixed anther has four lobes of which the outer two are bigger than the inner (Figs. 29, 30). In transverse sections the young anther also presents a somewhat quadrangular outline. Three to four archesporial cells differentiate in the hypodermal layer at each corner (Fig. 31). These archesporial cells divide periclinally (Fig. 31) to cut off the primary parietal layer and the sporogenous tissue. In a fully formed anther the wall layers consist of a thick epidermis, a large celled endothecium, two to three middle layers and a single or, at places, two layers of tapetum (Fig. 32).

The epidermis, which is thick walled, soon gets cuticularised and cutinised to persist till the end, excepting at the places of dehiscence of the anther. In *S. album* the cutin is deposited on the entire cell wall of the epidermis, so that the lumen is considerably reduced (Figs. 33, 34). In *S. yasi* the epidermal cells show cutinisation on the outer and the radial walls only.

The endothecial cells are large and isodiametric in the beginning. They undergo considerable radial elongation at the maturity of the anther. As the lumen of the epidermal cells is already much reduced due to excessive cutinisation of their walls in *S. album*, it appears as if the endothecium is bounded externally by a very thick and cutinised wall (Fig. 34). The endothecial cells develop feeble fibrous thickenings quite late when mature pollen grains have been formed in the anther (Fig. 34).

Of the middle layers the inner one or two, as the case may be, are crushed and degenerate with the commencement of the reduction division in the microspore mother cells (Fig. 33). The outermost middle layer degenerates later during the development of the pollen grains. Iyengar (1937) has, however, stated that there is only one layer intervening between the endothecium and the tapetum in *S. album*. Evidently he has missed the inner layers which degenerate earlier.



TEXT FIGS. 29—52, Microsporogenesis and development of the male gametophyte. (Figs. 30, 36, 45 & 49, *S. yasi*; rest *S. album*). Figs. 29, & 30, anthers showing two large and two small lobes in t. s. and l. s. respectively. Fig. 31, t. s. anther lobe with male archesporial cells dividing periclinally. Fig. 32, t. s. anther lobe showing the wall layers and microspore mother cells.

The tapetal cells, which have a quite dense cytoplasm in the beginning, enlarge and get highly vacuolated as the anther grows in size (Figs. 32, 33). Their nuclei divide by ordinary mitosis and the cells become multinucleate (Fig. 33). Though as many as ten nuclei may be seen in some of the tapetal cells, four-nucleate condition is most frequent.

Generally there is only one layer of tapetum, but frequently at places two layers have also been observed in perfectly median sections of the anthers (Figs. 32, 33). The mode of origin of the second layer of tapetal cells is, however, not always very clear. Singh (1952), who also saw two layers of tapetum at places in the anthers of *Dendrophthoe falcata*, states that such a condition may be due to the sterilisation of the sporogenous cells situated near or below the tapetum.

In *S. album* the tapetum shows signs of degeneration *in situ* usually quite early when microspore mother cells are undergoing the reduction divisions. The empty walls of the degenerated cells are recognisable for a long time (Fig. 34). In *S. yasi* the tapetum degenerates slightly later when microspores have been formed.

Microsporogenesis.—The deeply stained sporogenous tissue, divides twice or thrice in all planes to form several compactly arranged microspore mother cells (Fig. 32). These cells begin to round up later on and acquire a more or less oval shape with the nucleus situated at the narrow end (Fig. 33). A mucilagenous wall also develops, and at the time the microspore mother cells enter upon the reduction divisions, they are surrounded by thick hyaline wall.

Quite a large number of microspore mother cells undergo the usual heterotypic changes and proceed to divide. Normally the homotypic division follows quickly, resulting in the formation of microspore tetrads arranged in a tetrahedral or isobilateral manner (Figs. 35, 36). Cytokinesis takes place simultaneously by furrowing of the mucilagenous wall, which extends inward ultimately dividing the cytoplasm into four parts. Rao (1942) has shown that in *S. album* cytokinesis takes place primarily by an ingrowth from the 'special wall' (mucilagenous wall), and cytoplasmic constrictions are secondary.

Fig. 33, l. s. anther lobe with degenerated middle layers, vacuolate and multinucleate tapetal cells, and dividing microspore mother cells. Fig. 34, l. s. anther lobe showing endothecium with fibrous thickenings, degenerating tapetal cells and bi-celled pollen grains. Figs. 35 & 36, tetrahedral and isobilateral tetrads of microspores. Figs. 37 & 38, abnormal tetrads of microspores. Figs. 39 & 40, tetrads showing degeneration of one or two microspores. Figs. 41—44, microspore mother cells at different stages of cytomixis. Fig. 45, young microspores. Fig. 46, uni-nucleate pollen grain. Fig. 47, bi-celled pollen grain with generative cell cut off in one corner. Fig. 48, bi-celled pollen grain showing signs of germination. Figs. 49 & 50, tri-celled pollen grains. Figs. 51 & 52, germinated pollen grains with long pollen tubes, from smears of undehisced anthers. Figs. 29, & 30, × 45; figs. 31, 44, 48, × 475; figs. 32, 33, × 275; figs. 34, 51, 52, × 340; figs. 35, 36-43, 45 47, 49 & 50, × 600.

An abnormal feature observed in *S. album* is the variation in the number and size of microspores that are produced at the end of meiosis by one microspore mother cell. Thus quite frequently only three cells are organised, of which one cell is bigger and two-nucleate, while the other two are uni-nucleate (Fig. 37). Iyengar (1937), who has also observed this abnormality in *S. album*, states that, "In the second division of some of the microspore mother cells some nuclei never divide after interkinesis but swell up". In the present investigations, however, it has also been found that both the nuclei of a dyad may divide but during cytokinesis two of them are surrounded by a common wall, to form binucleate cells. The further development of such bi-nucleate cells is, however, uncertain. most probably they degenerate.

In other cases some microspore nuclei have been observed to divide further so that more than four microspores of varying sizes are produced, surrounded by one mother cell wall in *S. album* (Fig. 38). These degenerate either in the mother cell wall or soon after separation, and form a structure quite comparable to periplasmodium, which is utilised in the nourishment of the healthy microspores. All the microspores of a normal tetrad are also not uniformly functional, so that sometimes one or two of them degenerate soon after their formation (Figs. 39, 40). Normal microspores after their separation from the tetrad have also been observed to disorganise and degenerate.

It may be pointed out here that in *S. album* the tapetum is consumed quite early during the divisions of the microspore mother cells. The sterilisation of the microspores probably, therefore, is an alternative source of nourishment for the developing pollen grains at this stage. Since the sterilisation of the sporogenous tissue, to form a subsidiary tapetum for additional nourishment, is a phenomenon of common occurrence in the allied family Loranthaceae (Singh, 1952) and also other families (see Maheshwari, 1950), it should not appear strange if the sterilisation is brought about at a later stage in *S. album* for the same purpose.

Cytomixis.—Sometimes during the first anaphase of meiosis in microspore mother cells the chromosomes are unevenly distributed to the two poles, resulting in the formation of dumble shaped restitutional nuclei. In such cases the second division fails. Two such cells with restitutional nuclei, lying nearer, become connected with each other through narrow projections, forming a sort of conjunction tube (Fig. 41). This brings about the mixing of the cytoplasm as well as the nuclear contents of both the cells. The connecting tube gets widened later on so that the two cells ultimately become confluent in one (Figs. 42, 43). Cytomixis may also take place between two cells showing the failure of second anaphase (Fig. 43) or even between two tetranucleate mother cells (Fig. 44).

Gates (1911) described this phenomenon of cytomixis for the first time in the microspore mother cells of *Oenothera gigas* and *O. biennis*, both of which are polyploid species. In *Lathraea* (Gates and Latter, 1927) cytomixis has been shown to occur during interkinesis, while in *Coreopsis tripteris* (Gelin, 1934) at the close of the meiotic divisions. Chromosome extrusion was also observed in the microspore mother cells of *Striga euphrasioides* (Kumar and Abraham, 1941), which is a parasitic plant.

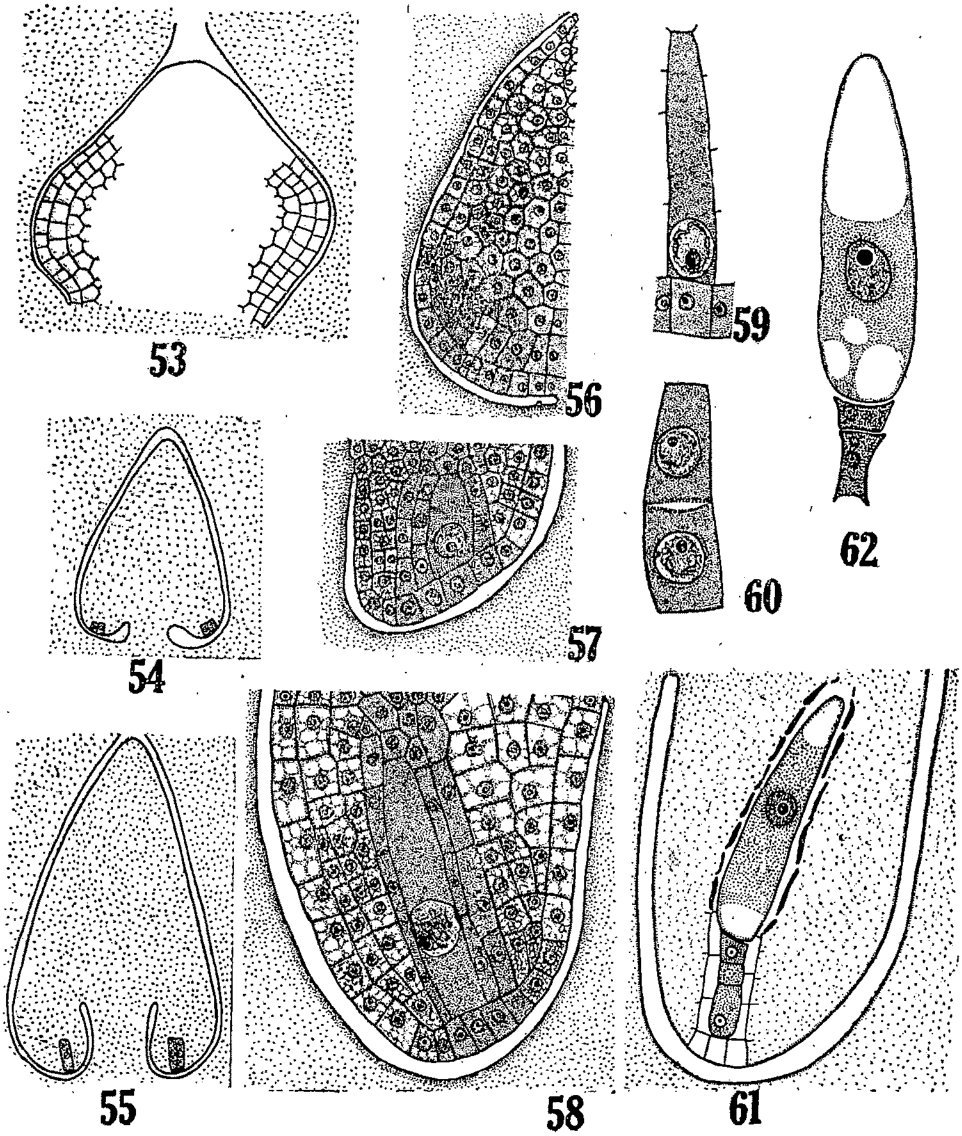
Cytomixis is believed to be a pathological phenomenon or the result of faulty fixations. Woodworth (1931) states that cytomixis is more commonly observed when a little extra pressure is used in squeezing out the mother cells during smear preparations. The author, however, thinks differently because what appears in smears to be a case of cytomixis of the two cells may really be a mechanical mixing of the oozed out cytoplasm of two burst cells, as a result of undue pressure applied during smearing. In such cases no formation of a conical projection can be observed as is seen in true cytomixis of *S. album*. Secondly cytomixis is not usually observed in normal microspore mother cells, dyads or microspores but only in those cells which show the presence of restitutional nuclei or similar other irregularity of division.

Development of the male gametophyte.—The young microspore is full of dense cytoplasm, and is somewhat oval with the nucleus situated in the centre (Fig. 45). As it enlarges usually a large vacuole appears and the nucleus is shifted to one side (Fig. 46). The first division of the microspore results in the formation of a large vegetative and a small generative cell, the latter being cut along the wall in a corner of the pollen grain (Fig. 47). The generative cell soon sets itself free (Fig. 48), and usually divides in the pollen grain itself to give rise to two male cells which come to lie in the centre of the pollen grain near the vegetative nucleus (Figs. 49, 50). The male cells are somewhat 'comma-shaped' and have an investment of their cytoplasm around them. In some cases they are seen to have considerably elongated (Fig. 50). Quite frequently the pollen grains begin to germinate *in situ* at the bi-celled stage (Figs. 48, 51, 52).

The mature pollen grains have a thin intine and a thick unadorned exine, which is discontinuous at three germ pores. When viewed from sides the pollen grains look somewhat ellipsoidal or oval, while from the top somewhat triangular.

Germination of the pollen grains.—It is seen that the bi-celled pollen grains start germinating *in situ* quite frequently before the flower opens. The pollen tubes, which are quite thin and long, pass through inter-cellular spaces of anther walls, to protrude out of it and proceed towards the gynaeceum.

It may be recalled here that some unicellular glandular hairs develop on the inner surface of the perianth lobes near the bases of the filament (see p. 197, & Figs. 10, 11). These hairs are quite long and completely arch over the anther. They appear to play some important role in the germination of the pollen grains *in situ*. It is revealed from anthesis studies that some shiny secretion oozes out of the hairs at the surface of the anthers. It very likely provides a medium for the growth of the pollen tube along the anther wall. Rao (1942) has mentioned the germination of pollen grains in the undehisced



Text Figs. 53—62, Showing the development of the ovule and megasporogenesis. (Fig. 59, *S. yasi;* rest *S. album.*)

Fig. 53, l. s. ovary with ovule primordia. Figs. 54 & 55, l. s. ovary showing the ovules at megaspore mother cell stages. Fig. 56, l. s. ovule showing the differentiation of female archesporial cells. Fig. 57, l. s. part of an ovule showing young megaspore mother cell. Fig. 58, l. s. part of an ovule with an elongated megaspore mother cell. Note the small and vacuolate integumentary tissue is distinct from the densely cytoplasmic and elongated cells of the nucellus. Fig. 59, l. s. megaspore mother cell with its nucleus lying at one end. Fig. 60, l. s. dyad. Fig. 61, l. s. ovule with a linear tetrad of megaspores. The chalazal megaspore has elongated. Fig. 62, l. s. linear tetrad of megaspores. Note only two degenerating cells capping the functional megaspore. Fig. 53, × 200; figs. 54 & 55, × 60; figs. 56-59, × 350; figs. 60, 61, × 425; fig. 62, × 600.

anthers of *Thesium wightianum*, where also the glandular hairs arch over the anthers. He has however not attached any importance to these hairs.

Ovule.—The ovule initials arise, as small protuberances, in immediate contact with the inner epidermis of the ovary (Fig. 53) by active divisions of the epidermal and the hypodermal cells in lateral positions at three places near the tip of the young free-central placenta. Early growth of these ovules is almost at right angle to the placenta. Later on, due to increased anticlinal divisions on the upper and outer side of each of the three ovules, they begin to curve in the downward direction and ultimately become pendulous (Figs. 54, 55).

The young ovular protuberance consists of homogenous meristematic tissue (Fig. 53). As the archesporial cells differentiate some cells of the nucellar epidermis on their sides become slightly differentiated from the rest and undergo anticlinal divisions. Quick anticlinal and periclinal divisions take place in the cells of hypodermis also below the differentiated epidermal cells. This results in the formation of a tissue composed of small cells with vacuolated cytoplasm (Fig. 57), which is clearly differentiated from the one or two layers of richly protoplasmic and elongated cells present in immediate contact with the megaspore mother cell. This difference becomes more marked in later stages when the megaspore mother cell is considerably enlarged (Fig. 58). The ovule at this stage thus shows two well marked tissues, (a) the inner formed of megaspore mother cells and the enveloping one or two layers of densely cytoplasmic cells, representing the nucellus; and (b) the outer small and vacuolated cells surrounding it, representing the single integument, which is growing in complete union with the nucellus. The downward growth of the ovule is mainly brought about by cell divisions of the integumentary tissue, while the nucellar cells simply elongate to keep pace with the growth of this integumentary tissue.

As the integumentary tissue in these species of *Santalum* does not grow beyond the level of the nucellar tissue, no micropyle is formed. On account of the fusion of the bases of ovules with the placenta for a considerable length, the funiculus is also not marked out. Both these characters indicate towards the reduced nature of the ovule. But considering the position of the pendulous ovule, its free end pointing down in the ovary should be regarded as micropylar, while the attachment region as the chalazal side.

The difference between the nucellar and the integumentary tissue remains quite marked up to the tetrad of megaspores stage, after which the nucellar cells are crushed by the growth of the functioning megaspore (Fig. 61). Some integumentary cells are also crushed during the development of the embryo sac. The whole integumentary tissue is, however, finally crushed, along with the placenta, by the endosperm.

Probably due to the complete absence of micropyle in the ovules of *Santalum*, the presence of integument could not be detected by any of the previous workers.

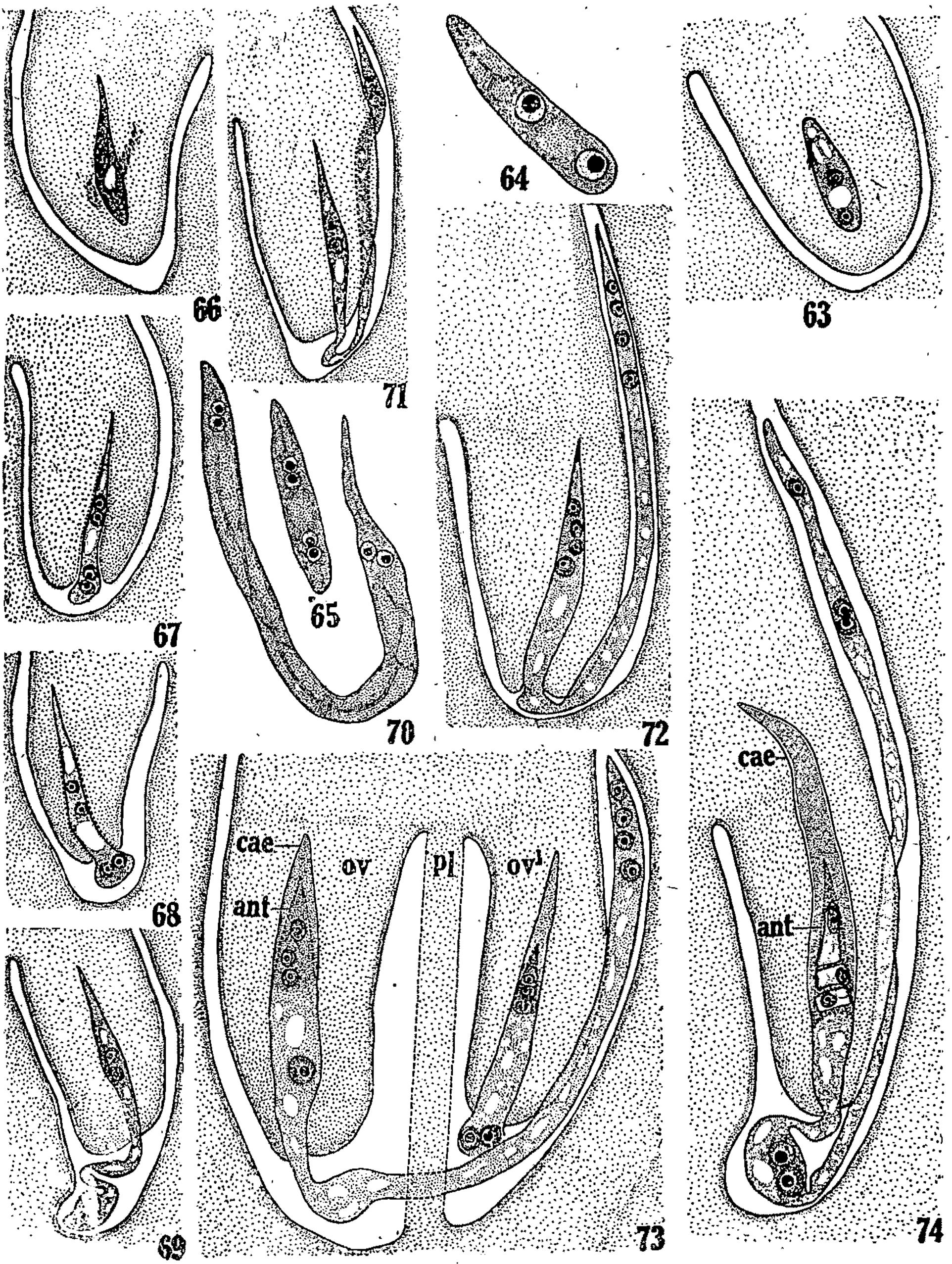
Iyengar (1937) had observed in the ovules of *S. album* one or two layers of richly protoplasmic cells surrounding the megaspore mother cells on the sides and quite distinct from the remaining cells of the ovule. He, however, confused these to be tapetal cells in a purely functional sense, thinking that the inner layer of the massive naked nucellus had taken up a nourishing role.

Megasporogenesis.—Two to four cells in the hypodermis of the young ovular protuberance enlarge and differentiate as archesporial cells (Fig. 56). By the time the ovule bends down, one or two of these archesporial cells directly become megaspore mother cells (Fig. 57). This is contrary to Iyengar's (1937, p. 180), findings on *S. album.* He states that, "The archesporial cell soon divides by a periclinal wall to form a parietal and sporogenous cell. The parietal cell, at times, divides by anticlinal and periclinal walls so that the sporogenous tissue becomes deeply lodged." Rao (1942, p. 160) has also made a very dubious statement that, "The hypodermal mother cell gradually becomes embedded deep in the tissue of the nucellus." These conclusions seem to have been drawn from the study of sections showing some of the lateral integumentary cells capping the megaspore mother cell in obliquely cut ovule. The previous workers on *Osyris* and *Thesium* spp. (Schulle, 1933; Rutishauser, 1937; Schaeppi and Steindl, 1937) have all reported that the archesporial cells directly function as megaspore mother cells with no wall layers capping them.

The megaspore mother cell elongates considerably without much appreciable increase of its width (Fig. 58). The nucleus is sufficiently enlarged by this time and occupies the whole width of the cell. In the earlier stages the nucleus is situated near the centre of the cell, later it moves up and can be frequently seen to lie at the upper end of the megaspore mother cell (Fig. 59).

The heterotypic division of the megaspore mother cell results in the formation of the dyad cells (Fig. 60). Usually both the cells immediately undergo the homotypic division, and a linear tetrad of megaspores is formed (Fig. 61). Quite frequently only two degenerating cells are observed capping the functioning megaspore (Fig. 62), indicating that the micropylar dyad cell may not divide simultaneously with the other dyad cell, and the former may degenerate even before completing the second division.

Development of the female gametophyte.—The megaspore lying towards chalazal end is functional. It enlarges and develops characteristic vacuoles at its two poles, with the nucleus in the centre. Other megaspores lying towards micropylar side soon degenerate (Figs. 61, 62). Iyengar (1937) has also stated that in *S. album* the lowest (chalazal) megaspore functions. Rao (1942) has, on the other hand, reported that in *S. album* the micropylar megaspore functions. This observation of Rao should be taken with caution, for in such plants where the micropylar end of the embryo sac grows out of the ovule and is hidden, the antipodal cells can be very easily



TEXT FIGS. 63—74, Stages in development of the embryo sac. (Figs. 63, 68 & 69, *S. yasi*; rest *S. album*).
(*ant*, antipodals; *cae*, chalazal caecum or embryo sac haustorium; *ov*, ov^1, ovules; *pl*, placenta).

Fig. 63, l. s. ovule showing a bi-nucleate embryo sac. Fig. 64, an excised bi-nucleate embryo sac. Fig. 65, an excised young four-nucleate embryo sac. Fig. 66, l. s. ovule showing a four-nucleate embryo sac with pointed chalazal tip. Figs. 67—69, l. s. ovules showing four-nucleate embryo sacs with micropylar end elongated to protrude in the ovary cavity. Fig. 70, mistaken for the non-functional megaspores, while the arm of the embryo sac in the ovule, with the lower polar nucleus in it, looks like an elongated functioning megaspore. A similar case has been described by Maheshwari and Singh (1952) in *Macrosolen cochinchinensis* where Treub (1881) and Schaeppi and Steindl (1942) mis-interpreted the antipodal cells to be three non-functional megaspores.

The first division of the megaspore nucleus results in the formation of a bi-nucleate embryo sac, which is a small and unelongated structure (Figs. 63, 64). Soon after the four-nucleate embryo sac is formed, its chalazal end grows as a pointed tip (Figs. 65, 66), that travels mostly through intercellular spaces. The micropylar end of this four-nucleate embryo sac also starts elongation after a short while. Iyengar (1937) and Rao (1942) have, however reported that the micropylar elongation of the embryo sac starts at the bi-nucleate stage when it comes out of the nucellus to peep into the ovary cavity. This is contrary to the findings of the present author. From the study of microtome sections (Fig. 63) as well as of the excised embryo sacs (Fig. 64), it has become very clear that the two-nucleate embryo sac is comparatively a small structure and shows no micropylar elongation. Further a close series of a large number of four-nucleate embryo sacs of different sizes has been obtained by microdissections as well as in sections of both *S. album* and *S. yasi* (Figs. 65-71). These clearly indicate that the micropylar elongation of the embryo sac starts only after the four-nucleate stage has been reached.

With the commencement of the micropylar elongation, the chalazal growth of the embryo sac is slowed down. The mircropylar end of the embryo sac widens and crushes the nucellar epidermis (Figs. 67, 68), and soon grows out of the ovule where it brings about a slight disorganisation of the cells of the base of the ovary cavity (Fig. 69).

The tip of the embryo sac now bends laterally and starts growing up along the surface of the ovule towards the style. Sometimes, however, the bend of the embryo sac may take place towards the placental stalk, and after passing by its side and the ovule on the other side, it grows up in the space between the ovule and the ovary wall. Thus two to three embryo sacs from different ovules can be seen growing side by side in the ovary cavity on one side only. Irrespective of the direction of the initial growth, the embryo sac soon acquires a 'U' shaped structure (Fig. 70). During this elongation the tip, which was swollen when it came out of the ovule, becomes considerably

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an excised four-nucleate embryo sac, which has elongated to acquire the shape of 'U.' Fig. 71, l. s. ovule showing a 'J'-shaped four-nucleate embryo sac. Fig. 72 l. s. ovule showing an eight-nucleate embryo sac. Fig. 73, l. s. ovary showing an 'U'-shaped eight-nucleate embryo sac, with just formed chalazal caecum. In the other ovule is seen the lower-part of a slightly advanced embryo sac. Fig. 74, l. s. ovule with a 'J'-shaped organising eight-nucleate embryo sac. Figs. 63, 66—69, 71—74, × 200; fig. 64, × 520; figs. 65, 70, × 300.

thinned and pointed. The bend of the 'U' may become slightly wider and swollen, while the arms remain narrow. The author agrees with Rao (1942) that there are no outgrowths or branches of the bent portion at this stage, as were reported by Henfrey (1856). A few folds or loops which are sometimes formed in the bend are also straightened as the embryo sac grows up.

Because of the continued growth of the micropylar* tip in the ovary cavity, the free arm of the embryo sac becomes longer than the arm inside the ovule, so that the 'U' shaped embryo sac now becomes 'J' shaped (Fig. 71). The nuclei do not remain at the thin and pointed tips of the embryo sac, but lie some distance behind. The third division of all the nuclei of the embryo sac, to form a micropylar and a chalazal quartet, takes place at this stage. The upper or micropylar nuclei lie in a row in the upper part of the free arm of 'J', with the chalazal quartet formed at the base of the embryo sac deep in the ovule (Figs. 72, 73).

The upper polar nucleus travels down to reach the swollen bend of the embryo sac. The lowar polar nucleus also emerges out of the ovular premises in the swollen bend, where the two nuclei lie adpressed against each other (Fig. 74). The nuclei destined to form the egg apparatus remain at the upper end of 'J' and those, that will form the antipodals, at the lower end of 'J' which is embedded in the ovule (Fig. 74).

As soon as the eight-nucleate stage of the embryo sac is reached, a chalazal outgrowth develops laterally a short distance above the antipodal end of the embryo sac (Figs. 73, 74). This thick walled lateral caecum, the chalazal embryo sac haustorium, penetrates the tissue of the ovule and then bends down to enter the placental stalk. This caecum which invariably grows in a line with the antipodal end (Figs. 73, 74), has been erroneously considered to be a prolongation of the chalazal end of the embryo sac by all the previous workers on *Santalum*. A study of the excised complete embryo sacs (Paliwal, 1953), however, showed that the antipodals are always left *in situ* at the lower tip of the embryo sac (*ant*) and that the chalazal haustorium (*cae*) develops laterally from the embryo sac just above the antipodals (Figs. 75, 76). Such lateral chalazal caecum has also been reported in *Macrosolen cochinchinensis* (Maheshwari and Singh, 1952).

In *S. album* the chalazal caecum on entering the placenta grows down towards the base of the ovary, disorganising the cells in its path. Thus finally the mature embryo sac acquires the shape somewhat like 'N' (Figs. 76, 77). In *S. yasi*, on the other hand, the chalazal caecum continues to grow upward in the mamelon destroying the cells of its elongated beak. Thus in this species the mature embryo sac acquires again a 'U' shaped structure (Fig. 78). The chalazal embryo sac haustorium has been described further under post-fertilization changes.

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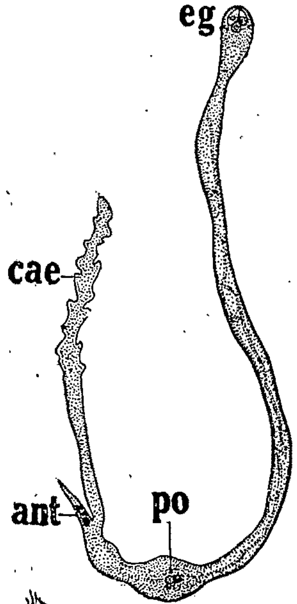
*The term micropylar has been used hereforward in reference to the original position of the embryo sac in the ovule, prior to elongation, to understand the orientation of the embryo sac.



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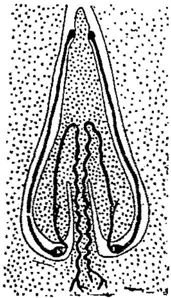

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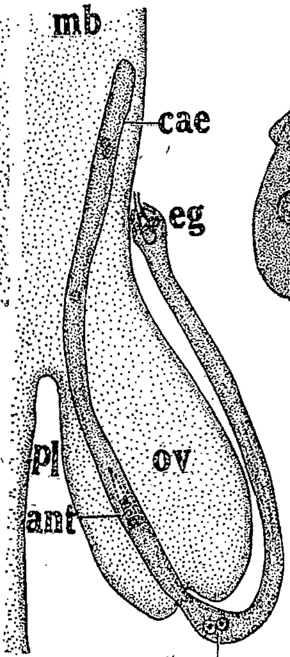

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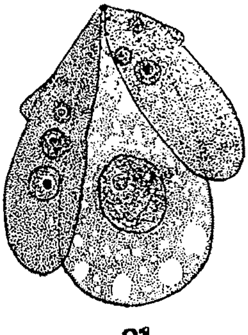

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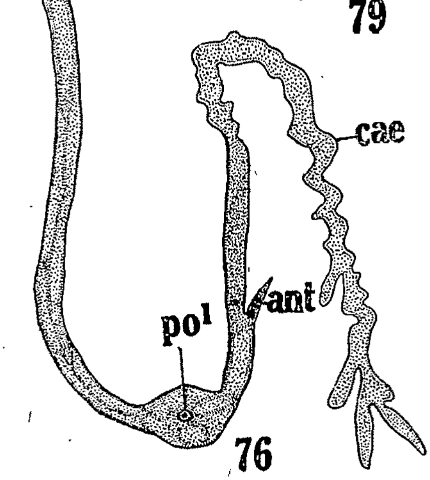

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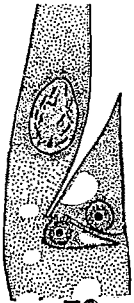

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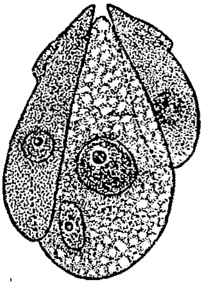

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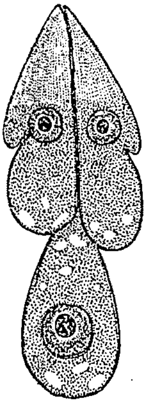

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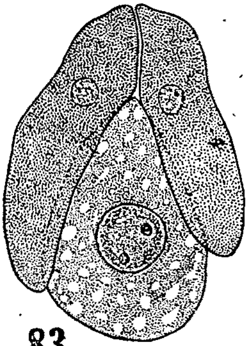

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Text Figs. 75—83, Showing the mature embryo sacs and their components. (Figs. 78, 80, *S. yasi;* rest *S. album.*) (*ant,* antipodals; *cae,* chalazal caecum; *eg,* egg apparatus; *mb,* beak of the mamelon; *ov,* ovule; *pl,* placenta; *po,* polar nuclei; *po,*[1] polars fused.)
Fig. 75, an excised mature embryo sac. Fig. 76, an excised embryo sac,

Figures 75 and 76 show the mature embryo sacs of *S. album* and Fig. 78 that of *S. yasi*. Each consists of an egg apparatus (*eg*) lying at the upper end of the embryo sac in the ovary cavity near the base of the style, two polar nuclei (*po*) closely adpressed against each other or fused (*po*^{1}) in the swollen bend of the embryo sac, and three antipodal cells (*ant*) lying deep in the ovule. The position of the mature embryo sac of *S. album* in the ovary has been shown in the diagram 77.

The antipodal cells are organised earlier than the other cells of the embryo sac. It is interesting to find the antipodal nuclei in the prophase stage of mitotic division in some cases. The complete division of these nuclei and the consequent increase in the number of antipodals, however, has not been observed in *S. album*. In *S. yasi*, on the other hand, in several cases more than three antipodal nuclei are observed. In embryo sacs of this species some nuclei are also seen scattered in the chalazal embryo sac haustorium (Fig. 78). This condition may be observed in the embryo sacs showing two polar nuclei hard pressed with each other. Presumably, therefore, these extra nuclei are formed as a result of division of the antipodal nuclei, some of which are pushed into the chalazal caecum. In *S. album* in one or two cases only one antipodal nucleus in prophase stage was observed entering the chalazal embryo sac haustorium (Fig. 79). In such case only two antipodal nuclei were organised into cells. Rao (1942) has reported that in *Scleropyrum wallichianum* the antipodal nuclei, which are not organised into cells, multiply and migrate into the chalazal haustorium.

Generally, as a rule, there are three antipodal cells. Sometimes, however, only two cells may be organised, one of which, usually the upper, is binucleate. They usually lie in a linear row, but in some cases the upper two cells may lie side by side oblique to each other. Each cell has two to three conspicuously big vacuoles at the corners, with the nucleus in the centre. The antipodal cells are quite persistent and may be seen up to the time of endosperm formation. Iyengar's (1937) report that in *S. album* the antipodals are ephemeral and disorganise early, is unconvincing in view of the observations given above. It seems that Iyengar who considered the lateral caecum to be antipodal haustorium, paid no attention to the separate pouch carrying the antipodal cells, which were thus considered by him to be ephemeral.

As already stated, soon after the eight-nucleate stage the polar nuclei

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which, along with its caecum, has acquired the shape of the letter inverted 'N.' Fig. 77, diagram showing the position of the embryo sacs of *S. album* in the ovary cavity. Fig. 78, an excised mature embryo sac of *S. yasi*, shown in its position. Note the well developed chalazal caecum growing up in the mamelon, and the presence of three nuclei in the caecum. Fig. 79, a part of the embryo sac showing one of the antipodal nuclei in the prophase stage of division, entering the chalazal caecum. Fig. 80, l. s. egg apparatus. The synergids are beaked and have a filiform apparatus. Fig. 81, l. s. egg apparatus of *s. album*. The synergids in this particular case are abnormal, having three nuclei each. Fig. 82, l. s. egg apparatus in the process of fertilization. Fig. 83, l. s. fertilized egg apparatus. Figs. 75, 76, 78, × 45; figs. 79, 80, × 425; figs. 81—83, × 600.

start travelling to the middle of the embryo sac. All the nuclei of the embryo sac at this stage are of the same dimension, but along with their movement the polar nuclei increase much in size, until they come to lie near each other in the swollen bend of the embryo sac. The upper polar has to travel on an average a distance of 1500-2000 μ to reach this bend while the lower polar has to travel a much shorter distance for the same.

The egg apparatus is organised at the free end of the embryo sac in a small pocket formed in mamelon (Fig. 77). With the organization of the egg apparatus the upward elongation of the embryo sac is stopped. Sometimes two egg apparatus belonging to two embryo sacs from different ovules, or rarely developed in the same ovule, as in *S. yasi,* can be seen lying side by side in one pocket.

The egg cell is conical with its nucleus situated in the middle or towards the base, and is full with finely vacuolated cytoplasm (Figs. 80-83). In *S. album,* a considerable part of the egg cell is covered by the synergids, while in *S. yasi,* it is appreciably longer.

The synergids are long and pear shaped. They are notched in the middle and thus their body is clearly divided into the upper and the lower halves (Figs. 80-83). The lower half of the synergids is darkly stained, whereas the upper half is lighter and shows fine striations of the filliform apparatus running lengthwise (Fig. 80). In *S. album* in later stages the upper half of the synergids gets more darkly stained than the lower half (Figs. 82, 83).

The synergids are persistent in both species. Their tips project out of the embryo sac by disorganising its apical membrane (Figs. 76, 78) and later form the synergid haustoria which will be described in the post-fertilization changes. It is interesting to find that in *S. album* sometimes the synergids are found to be having more than one nucleus each. Figure 81 shows an egg apparatus where each synergid is three-nucleate. In all probabilities these nuclei are formed by divisions of the primary synergid nucleus. In view of the fact that the synergids in this plant have haustorial function, the increase in the number of nuclei may be due to this unusual function.

Fertilization.—It has been pointed out earlier that quite frequently the pollen grains germinate *in situ.* Some pollen tubes are found even to pierce the gynaeceum in the stigma or stylar region at various levels. These may reach an embryo sac before or after the flower opens. Thus the fertilization may be affected either in the closed condition or in open flowers. A number of pollen grains are also observed on the stigma of the open flowers, but it could not be ascertained if they germinate and affect fertilization.

The entry of the pollen tube in the embryo sac causes no harm to the synergids. Iyengar (1937) has, however, reported that the pollen tube pierces between the synergids, disorganising both of them as is indicated by their having taken a dark stain soon after the entry of the pollen tube. Rao (1942) on the other hand reports that if the pollen tube enters between the synergids, none of them is destroyed, but if it enters from one side it destroys one of the synergids.

Both male cells are discharged in the vicinity of the egg cell. A number of cases have been observed in which one of the sperms had entered the egg cell and was lying by the side of the egg nucleus prior to its actual fusion (Fig. 82). The other sperm travels down the arm of the embryo sac and triple fusion occurs in the swollen bend.

Iyengar (1937) states for *S. album* that, "The pollen tube after getting into the egg cell approaches very near the egg nucleus. The tip of the pollen tube bursts and one sperm nucleus is discharged very near the egg nucleus". He has also given a figure showing the pollen tube still persistent in the egg cell. He further reports that in *S. album* there is no double fertilization and that, "The first sign of the activity *(of the fusion nucleus)** becomes apparent at the time of the penetration of the pollen tube through the synergids. By the time the first male nucleus is discharged into the egg cell the first mitotic figure is seen in the fusion nucleus. The second male nucleus remains as a disorganised mass in the pollen tube". There is, however, a definite evidence of double fertilization in both the species of *Santalum* studied by the present author. The first division of the primary endosperm nucleus takes place much after the double fertilization has been completed. Rao (1942) has also reported that there is evidence of double fertilization in *S. album*.

Post-fertilization changes in the embryo sac.—The following interesting changes take place in an embryo sac soon after fertilization :

Chalazal embryo sac haustorium.—The origin of the chalazal embryo sac haustorium in the form of a lateral caecum has been described earlier (p. 211). There are three chalazal haustoria, one from each of the three embryo sacs developing in an ovary. Their activity is appreciably enhanced soon after fertilization. In *S. album* they follow a zigzag course through the placenta, invading and consuming the cells in their path. Soon, however, one of these haustoria overgrows the other two, when the growth of the latter slackens down. The vigorous haustorium sends off a number of branches, which ramify in the lower part of the placental stalk. Ultimately some of the branches extend deep into the solid region of the flower below the base of the ovary cavity and devastate its tissue for a considerable depth.

Different caecii growing side by side in one placenta do not completely fuse with each other as reported by Rao (1942), instead they remain separate which is quite clear only in microdissections. Since the disorganised part of the placenta forms a tubular structure, it can be easily mistaken for a fused haustorial tube in sections, specially because of the membranous nature of the walls of the haustoria.

The growth of the chalazal caecum in *S. yasi*, as already pointed out (p. 211) is directed upward in the mamelon. The branches from it ramify

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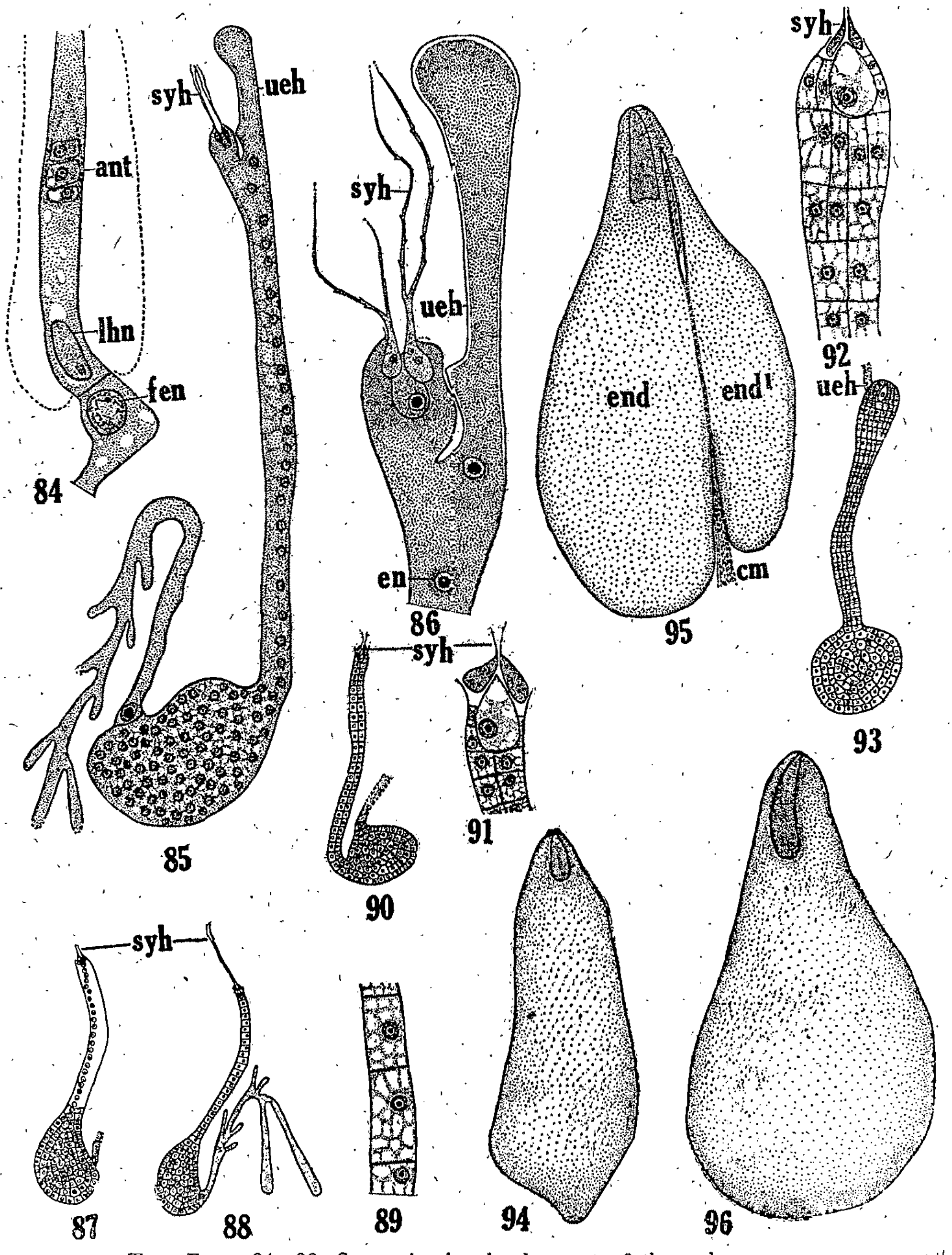
* *mine.*



TEXT FIGS. 84—96, Stages in the development of the endosperm.
(Figs. 84, 92, 94, *S. yasi*; rest *S. album*.)

(*ant*, antipodals; *cm*, crushed mamelon; *en*, free endosperm nuclei; (*end* & *end*^{1}, endosperms; *fen*, functional endosperm nucleus; *lhn*, lower haustorial nucleus; *syh*, synergid haustoria; *ueh*, upper endosperm haustorium.)

Fig. 84, l. s. part of the embryo sac, after the first division of the primary endosperm nucleus, showing a posterior compartment with haustorial nucleus (*lhn*) and the anterior compartment laterally in the upper part of the beak of the mamelon, while some of them may be directed sidewards towards the placental stalk.

Synergid haustoria.—The tips of the synergids project out of the embryo sac by disorganising its apical membrane. Narrow branched outgrowths arise from the apical ends of synergids at the time endosperm formation has started. They are the synergid haustoria (Paliwal, 1953), which are thin and membranous like branched pollen tubes (Figs. 85, 86). Schacht (1866) and Strasburger (1885) have described the development of a system of tubular canals from the synergids in *S. album.* Iyengar (1937) as well as Rao (1942) have also stated that the apical portion of the embryo sac is disorganised and the tips of the synergids project into the ovary cavity, but nothing further has been said about the development of these tips. Rao (1942), on the other hand has even refuted the development of any system of tubular canals from the synergids as described by Schacht and Strasburger. This may be due to the fact that the synergid haustoria are very narrow, hyaline and membranous structures, so that they easily escape observations in sections and can be observed in the whole mounts of embryo sacs only (Paliwal, 1953). Undoubted synergid haustoria have so far been reported only in some members of Compositae like *Ursinea calendula* (Dahlgren, 1924).

The synergid haustoria enter the tissue of the mamelon lying immediately above to protrude out at its tip and enter into the stylar canal or its tissue. The synergids along with their haustoria persist till quite late during the development of endosperm and embryo (Figs. 87, 88, 90, 91 92, *syh*). With the advanced growth of the endosperm, the synergids are, pushed slightly up and separated from the zygote. In later stages when the endosperm has acquired a conical shape and the well developed embryo is embedded deep in its tissue, the synergid haustoria get disorganised.

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with the functional endosperm nucleus (*fen*). Note the antipodals are yet persisting. Fig. 85, whole mount of embryo sac with free nuclear endosperm. Note the lower endosperm haustorium at one end, and the synergid and the upper endosperm haustoria at the other end. Fig. 86, a magnified view of the upper part of the embryo sac showing the synergid and the upper endosperm haustoria. Fig. 87, whole mount of endosperm which has become cellular in the 'bulla' but is free nuclear in the arm. Fig. 88, whole mount showing cellular endosperm. Note the presence of a single row of cells through out the arm, with synergid haustoria at its top. Fig. 89, a part of the endosperm in the arm (Fig. 88) more magnified to show a single linear row of cells. Fig. 90, a more advanced endosperm showing two row of cells in the arm. Fig. 91, a part of the endosperm in the arm (Fig. 90) more magnified. Note the zygote surrounded by the endosperm cells, and the synergid haustoria. Fig. 92, slightly more advanced endosperm than the above, showing four rows of cells close to the zygote. Fig. 93, whole mount of further advanced endosperm, with several cells in the 'bulla' and an increasing number of cells in the arm from top downward. Fig. 94, whole mount of massive endosperm acquiring a conical shape. Fig. 95, l.s. composite endosperm formed by the fusion of *end* and *end*^{1}. The crushed mamelon is present between them at places. Fig. 96, whole mount of a mature cone shaped endosperm with the embryo embedded at the top.

Figs. 84, 89, 91 & 92, × 200; fig. 85, × 75; fig. 86, × 300; figs. 87,88, 90, 93-96.

The endosperm haustoria.—Both lower (chalazal) as well as upper (micopylar) endosperm haustorial structures develop at the posterior and the anterior end of the embryo sac respectively. For the sake of convenience they are described along with the development of endosperm.

Endosperm.—The endosperm formation starts in all the mature embryo sacs. The first division of the primary endosperm nucleus is followed by the formation of a transverse wall which divides the embryo sac into two compartments (Fig. 84). The endosperm formation takes place only in the upper or micropylar chamber, while the endosperm nucleus in the posterior or chalazal compartment (*lhn*) functions as the lower (chalazal) endosperm haustorial nucleus. It does not divide further and always remains in the position where it is formed. Under the influence of this haustorial nucleus the activity of the chalazal caecum, which has already traversed quite deep in the tissue of the placenta, is greatly enhanced. It starts vigorous branching and ramifications in all directions (Figs. 85, 88). After devastating the tissue of the placental stalk, the haustorial branches penetrate deep below the base of the ovary cavity. The haustorial nucleus is hypertrophied quite early in *S. yasi*. In *S. album*, it persists in normal conditition for long and is hypertrophied only in later stages. The formation of this chalazal endosperm haustorium appears to be a very regular feature of the entire family Santalaceae and has been described in all the plants of this family studied so far (see Schulle, 1933 ; Iyengar, 1937; Rutishauser, 1937; Schaeppi and Steindl, 1937; Rao, 1942; Paliwal, 1953). Rao (1942) has reported that in *S. album* the first transverse wall laid down between the daughter endosperm nuclei does not reach the opposite walls of the embryo sac, and thus its separation into two compartments is not complete. He further writes, "The cytoplasm surrounding the posterior nucleus secretes at its surface a continuous membrane and constitutes a large cell occupying the entire sac. As a result of further elongation this cell assumes the shape of a cone, with the apex projecting into the antipodal haustorium (*the chalazal caecum*)*". Thus according to him the chalazal endosperm haustorium develops as a distinct cell inside the chalazal embryo sac haustorium. Such a condition could not be seen in the present observations.

In later stages a greater part of the chalazal endosperm haustorium is surrounded by the cellular endosperm and is embedded in it. Ultimately the haustorium is crushed by the extensive growth of the endosperm tissue.

The divisions in the endosperm, which are confined to the anterior compartment only, are at first free nuclear. Thus a large number of free nuclei are produced in the bend of the embryo sac, which swells all the more like a 'bulla' (Fig. 85). Some of these nuclei migrate into the free arm of the embryo sac, where they divide to form several nuclei. These nuclei are arranged in a linear row closer to the outer wall of the embryo sac away from the mamelon. At this stage another lateral caecum arises from the upper part of the embryo sac not very far below the zygote (Figs. 85, 86, *ueh*). One of the free endosperm nuclei comes to lie at the mouth of this caecum and seems to be responsible for the further growth of this structure, which is haustorial in function.

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* *Italics are mine.*

In a number of angiosperms both chalazal as well as micropylar endosperm haustoria are formed together; e.g. in Acanthaceae (Mauritzon, 1934), Boraginaceae (Svensson, 1925). Lobeliaceae (Hewitt, 1939; Subramanyam, 1949), Scrophulariaceae (Krishna Iyengar; 1937, 39, 40, 41, 42) and several others (see Maheshwari, 1950). The micropylar endosperm haustorium in Santalaceae has been shown to be present for the first time and could be made out only in the microdissections (Paliwal, 1953). It has a thick wall and a swollen tip, which destroys the tissue of the mamelon lying above it. Just as in the lower endosperm haustorium, the single haustorial nucleus neither divides further nor enters deep into the haustorium, but always remains at its mouth. In later stages this haustorium is cut off from the embryo sac due to the wall formation in the endosperm in the anterior compartment. The micropylar endosperm haustorium is, however, less prominent and aggressive in *S. yasi*.

The wall formation in the endosperm occurs first in the 'bulla' and takes place in all planes without any regular sequence (Fig. 87). It proceeds upwards in the arm in a regular sequence laying transverse walls, forming first a single row of endosperm cells throughout its length (Figs. 88, 89). Later divisions are for some time mostly longitudinal so that two (Figs. 90, 91), four (Fig. 92) and later several (Fig. 93) linear rows of endosperm cells are formed in the arm. At the tip of the arm the endosperm cells surround the undivided zygote.

The endosperm in the free arm of the embryo sac acquires concavo-convex surface on account of its pressing hard along the convex surface of the mamelon. In the whole mounts it resembles more or less the spathe of *Musa*.

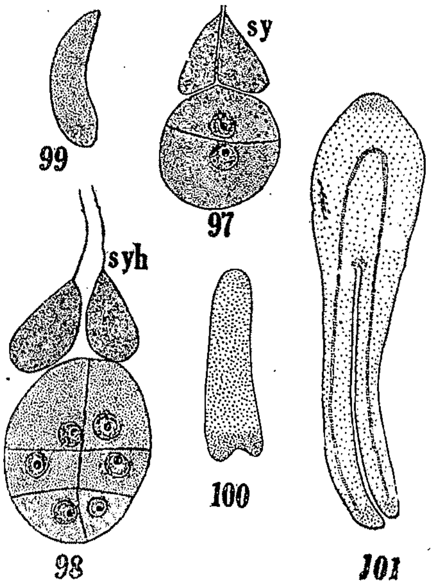
As already said, the endosperm formation starts in all the embryo sacs in an ovary. In later stages the growth of the endosperm in one or two embryo sacs may slow down and stop or it may continue in all the three. However, the endosperm tissue in one of the embryo sacs grows more vigorously than the others.

With the first division of the zygote the endosperm grows more actively. The swollen basal part of the endosperm becomes aggressive on the tissue in the base of the ovary which is hollowed down to a considerable extent in the form of pits. The endosperm also becomes aggressive on the free part of the ovule, which is embedded in it, along with the lower endosperm haustorium contained three in, which are ultimately crushed and degenerated. The remaining part of the mamelon is also crushed between the endosperm tissues developing in the ovary cavity. In some cases when the endosperm develops in only one or two embryo sacs of an ovary, the displaced and disorganised mamelon escapes out as it is pushed to one side and can be seen attached to the outer surface of the endosperm. With the degeneration of the mamelon, the parts of the endosperm haustoria present there in, are also disorganised.

The endosperm soon becomes massive and acqires a conical form (Fig. 94). Utimately the endosperm tissue developing in different embryo sacs of an ovary fuses to form a composite structure (Fig. 95). The mature endosperm acquires the shape of a solid cone, embedding at its apex a single functional embryo (Fig. 96).

No previous worker on *Santalum* has described the formation of a composite endosperm. As will be seen later in other genera of Santalaceae probably the endosperm develops in only one embryo sac in an ovary cavity. In the allied family Loranthaceae the composite endosperm is formed in a number of genera as a regular feature (see Singh, 1952; Maheshwari and Singh, 1952), which generally encloses a single mature embryo.

Embryo.—The embryo development begins quite late when the endosperm formation has much advanced and the zygote is surrounded by the cells of the endosperm. This makes the observation on the early development of embryo very difficult.



TEXT FIGS. 97-101, Stages in the development of the embryo of *S. album*. (*sy*, synergids; *syh*, synergid haustoria).

Fig. 97, l.s. a bi-celled proembryo. Note the persistent synergids. Fig. 98, whole mount of a six-celled proembryo, with persistent synergids and their haustoria. Fig. 99, whole mount of an elongating embryo. Fig. 100, l.s. embryo slightly older than above, showing the differentiation of cotyledons. Fig. 101, l.s. mature embryo. Figs. 97,, 98, × 425; figs. 99, 100, × 40; fig. 101, × 25.

The first division of the zygote is transverse, to form a basal and an apical cell (Fig. 97). The next stage observed was a six celled embryo (Fig. 98). Iyengar (1937) has reported that the second division of a bicelled proembryo takes place by a longitudinal wall to give rise to a four-celled embryo. Both apical cells of this proembryo then divide by a transverse wall to give rise to a six-celled embryo. Johansen (1950) also appears to agree with this mode of embryo development.

Further divisional steps could not be followed because of the quickness with which they occur. The divisions are more in a transverse plane to form an elongated embryo (Fig. 99). It is, however, clear, that the derivatives of both, basal as well as apical, cells are utilised in the formation of the embryo and that no suspensor is formed. Both Iyengar (1937) and Rao (1942) have, reported the formation of a suspensor in *S. album*, but their figures showing this condition are not very convincing.

The differentiation of the embryonic parts starts quite late (Fig. 100). A mature embryo consists of two long and thick cotyledons, a short plumule and a thick radicle (Fig. 101). The epidermis on the outer surface of the embryo is much thick walled and gets cuticularised, especially at the radicle end.

Two embryos of *Santalum album* were found to have three cotyledons each. Iyengar (1937) has reported that the presence of three cotyledons in this plant is not very rare. In *Dendrophthoe falcata* also three cotyledons have been reported as an abnormality (Singh, 1952).

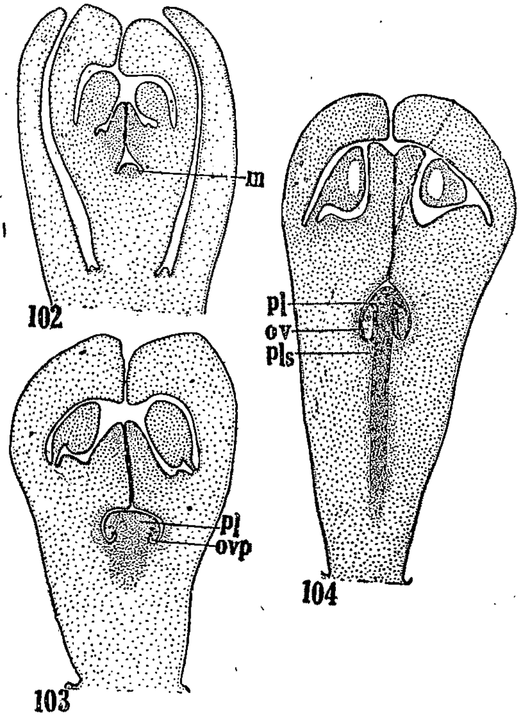
Strasburger (1878, 1885) as well as Iyengar (1937) have reported the presence of twin embryos. Iyengar has suggested that these might have developed from two embryo sacs originated in the same ovule either from two megaspores of the same tetrad or from two different tetrads. According to the present author, a greater possibility is that they might have developed from two embryo sacs belonging to two different ovules, but whose tips have come to lie side by side in the ovary cavity.

Osyris sp.

O. arborea Wall, is the only species of *Osyris* found in India. Its flowers are either male or seemingly hermaphrodite (really male-sterile). The present description deals with the latter type of flowers only.

Organogeny of flower.—The origin of the floral parts is in the regular sequence (namely perianth, androecium and gynaeceum) as described for *Satnalum* by the present author (p. 195) and *O. alba* by Schaeppi and Steindl (1937). The ovary wall grows up actively and soon closes to form small ovary cavity (Fig. 102), which is filled up completely by the growth of the mamelon (Figs. 103, 104).

Morphology of the flower.—The male-sterile flowers are solitary and axillary, pedicellate and much larger than the male flowers. The pedicel is flattened and at the point of junction with the flower it forms a circular disc like structure. On it are borne one bract and two bracteoles; all of which remain pressed against the flower. The bract as well as the bracteoles are caducous and fall off quite early, so that the disc is exposed as a circular rim at the base of the flower.



Text Figs. 102-104, Showing the organogeny and morphology of the flower of *O. arborea*. (*m*, mamelon ; *ov*, ovule ; *ovp*, ovule primordium ; *pl*, placenta ; *pls*, placental strand) Fig. 102, l.s. flower bud at the time of differentiation of mamelon primordium. Fig. 103, l. s. flower bud showing the differentiation of ovular primordia. Fig. 104, l.s. fully formed flower bud; note the placental strand, which is in continuation with the placenta, running through the solid portion of the ovary below the ovary cavity. Figs. 102, & 103 × 35; fig. 104, × 15.

The male-sterile flowers of *O. arborea* differ in several important features from flowers of other Santalaceae, as well as from the male flowers of the same species. The most outstanding differences are : (a) The perianth is represented as three small free lobes at the top of the ovary. It, therefore, appears to be polyphyllous in contrast to the gamophyllous condition found in others. (b) No glandular hairs develop in these male-sterile flowers. (c) The three lobes of the disc as well as the three stamens arise on the top of the ovary (Figs. 103, 104). Thus in contrast to the condition found in other flowers, they do not appear to be epiphyllous. The significance of this polyphyllous condition of the perianth, and stamens and disc growing on top of the ovary has been discussed later on.

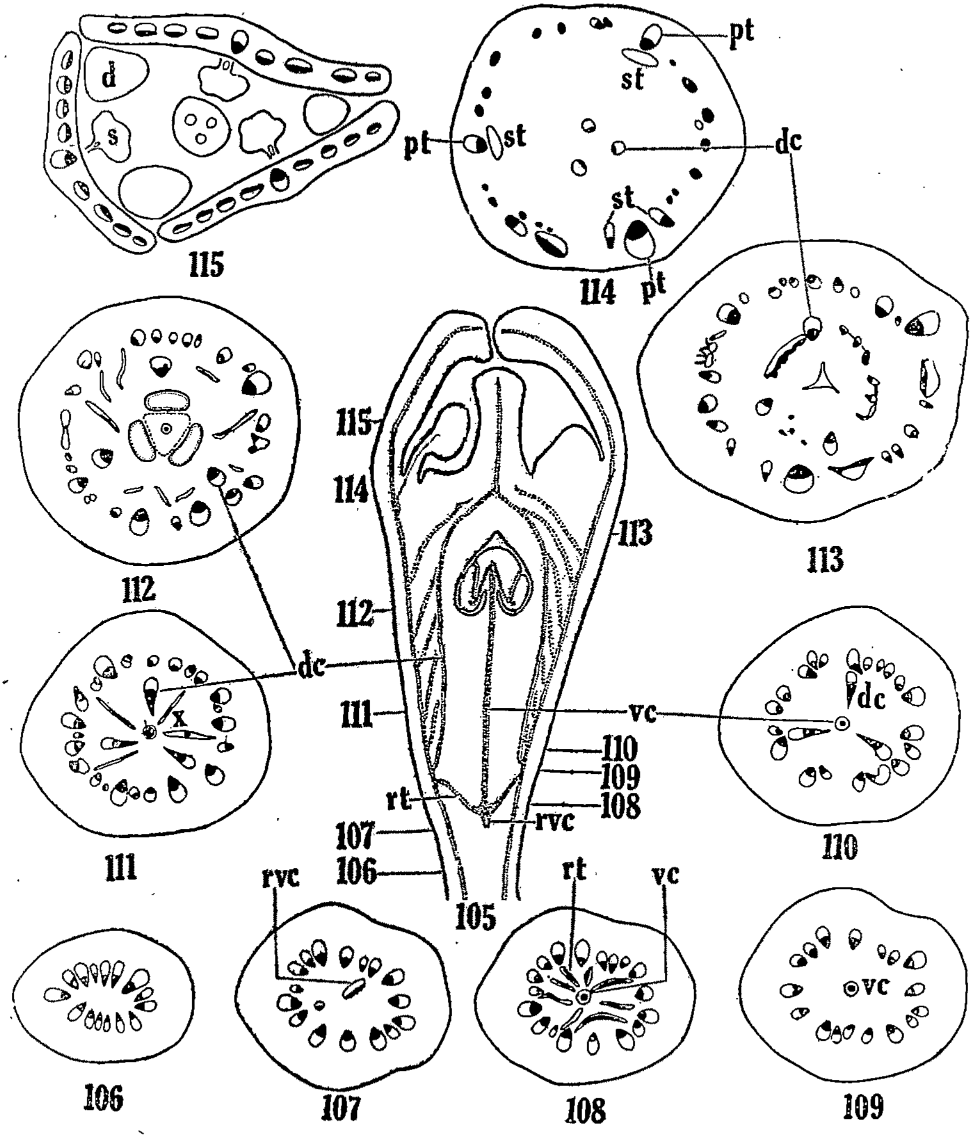
The gynaeceum is tricarpellary and syncarpous. The ovary is completely inferior with a very small unilocular cavity. As the flower grows three depressions or loculi appear at the base of the ovary cavity, in which the bases of the three ovules rest. In transverse sections the ovary, therefore, appears to be trilocular below and unilocular above. These depressions in the base of the ovary cavity are formed as a result of the downward growth of the ovules and a soldification of the ovary cavity around them. A close examination of the solid portion of the flower below the ovary cavity reveals that there is a clearly differentiated strand running through the central part of the flower (Figs. 103, 104 *pls.*). This strand is in continuation with the free central placental stalk in the ovary cavity. The ventral carpellary supply, which originates much below the level of the ovary cavity, runs through this central strand. These observations lead one to conclude that the central strand represents the tissue of the placenta passing through the lower part of the ovary which has now become solid, leaving a cavity only in its upper part where the ovules are borne. A comparison of the condition of the ovary of *Scleropyrum* (see Rao, 1942; Fig. 23, p. 156) with that of the ovary of *Osyris* would clear the situation better. If the lower portion of the ovary cavity of *Scleropyrum* is solidified, it would result in a condition much similar to that of *Osyris*. It is interesting to note that Rao (1942) has reported that in *Scleropyrum* the long placental strand fuses with the ovary wall in later stages of development. The present author, therefore, feels that the ovary of *Scleropyrum* shows an intermediary stage in the solidification of the lower part of the ovary cavity through the fusion of the placenta with the ovary wall in this region.

Laubengayer (1937) has also shown that the lower part of the ovary cavity in some Polygonaceous flowers becomes solidified. The base of the ovary cavity in these cases, according to him, is not the true base of the ovary, which is actually situated at a much lower level (where the dorsal carpellary supply is separated), while the ovary cavity appears abont one-third way up in the ovary. He has, therefore, concluded that the ovule in these flowers is not basal in the ovary but is only so in its cavity.

The small ovary cavity of *Osyris* is completely filled up with the thick and short mamelon, whose structure is very interesting. It has a small placental stalk and a heavy, globular head. From the head develop three pendulous structures which reach upto the base of the ovary cavity and then grow upward to form the ovules. Thus the ovules are pointing upward in the ovary, and not downward as in *Santalum* and *Thesium*.

The style is thick, short and is headed by three flapped stigmatic lobes. In longitudinal sections the epidermal cells, on both sides of the stylar canal, appear to be hard pressed so that practically no cavity is left (Figs. 103 104).

Vascular supply of the flower.—Index figure 105 shows the longitudinal course of the vascular supply. The numericals in this figure represent the



TEXT FIGS. 105-115, showing the vascular supply of the flower of *O. arborea*. (*d*, disc; *dc*, dorsal carpellary supply ; *pt*, perianth traces ; *rt*, recurrent traces ; *rvc*, residue of the ventral carpellary supply; *s*, stamen; *st*, staminal trace; *vc*, ventral carpellary supply, *X*, 'X' traces). Fig. 105, diagram showing the longitudinal course of the vascular supply. Figs. 106-115, t.s. at levels marked in the index figure 105. Explanation in the text. Fig. 105, × 15; figs. 106-113, × 25; figs. 114 & 115, × 19.

levels at which the transverse sections bearing the same numbers have been drawn.

The pedicel of the flower is traversed by several collateral vascular strands closely arranged in a ring. The first traces to depart from this ring supply the bracts and brecteoles. On entering the receptacle the main bundles divide and increase in number (Fig. 106). These continue to ascend obliquely upward for some distance in the flower, where a number of recurrent branches arise which bend down and travel obliquely inward and downward for some distance (Figs. 105. 108 *rt.*). All these branches anastomose with each other to form a central plate of vascular tissue in the pith, at the base of the flower. A few branches arise from this central plate, which travel upward and inward and soon fuse with one another to form a single amhhicribral strand (Figs. 105, 108-110 *vc*), which; after traversing through the solid portion of the ovary, enters the placenta and supplies the ovules. As described for *Santalum,* a few branches from the central plate of vascular tissue in *O. arborea* also continue to travel downward for some more distance to end blindly in the lower part of the flower (Figs. 105, 107, *rvc*).

The main vascular supply, after departure of the recurrent traces, continues upward and only after a short distance three strong normally oriented traces are given out from this ring (Figs. 105, 110*dc*). These represent the dorsal carpellary supply (Figs. 105, 110-112*dc*), and travel upward and inward undisturbed upto the roof of the ovary where they show anastomoses and finally branch to form a number of small bundles (Fig. 113). Most of these branches soon disappear leaving only three weakly differentiated ones which ultimately enter the style (Figs. 114, 115).

A number of irregular and weak traces also arise from the main ring at different levels apart from the dorsal carpellary supply (Figs. 105, 111, 112). These travel for some distance in the ovary wall and then most of them either fuse with the dorsal carpellary traces or end blindly in the ovary wall. As in *Santalum,* some bundles of the main ring which have given out 'X' traces, become inversely oriented. The outer ring of vascular supply is therefore formed of three groups of normally oriented bundles in the perianth positions with intervening groups of inversely oriented and weaker bundles (Fig. 113). Most of the latter disappear by and by before reaching the top of the ovary. A limited number of these only reach the ovary top where one bundle from each side of a perianth trace takes an inward swing to approach against the perianth trace. Such two inswinging bundles then fuse to form a compound bundle (Fig. 114 *st*) for each stamen. These staminal traces are mainly formed of phloem only.

Each large normally oriented trace meant for supplying perianth (Fig. 114, *pt*) divides further so that each perianth lobe receives nine bundles (Fig. 115). No vascular supply enters the disc.

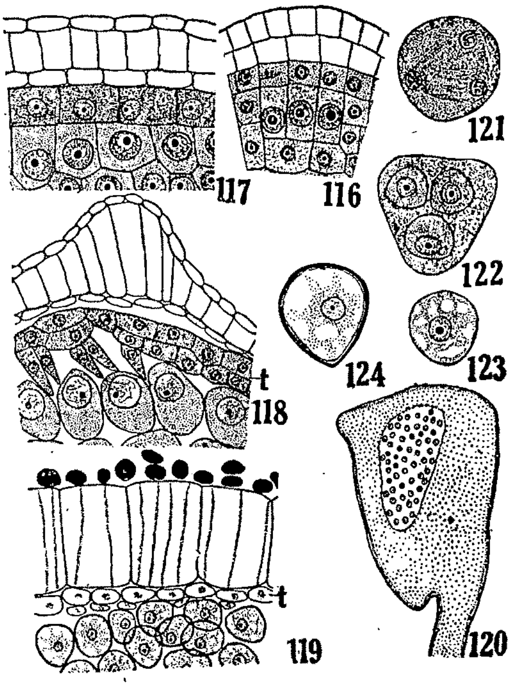
The floral anatomy of *Osyris* was first studied by Van Tieghem (1869 b). Schaeppi and Steindl (1937) have described the course of vascular supply in both male and female flowers of *O. alba.* At the base of the female flower they found apart from the main ring of vascular tissue, three bundles forming an inner ring, which they interpreted to be the carpellary bundles because of their absence in the male flowers. It is evident from their figure 5g, that these so called carpellary bundles anastomose with one another at a higher level and send the ventral carpellary supply. Thus these traces are actually continuation of the recurrent bundles as shown above by the present author in *O. arborea.* The latest work on the floral anatomy of *O. alba* is that of Smith and Smith (1942). They have reported the presence of a recurrent ring of inversely oriented bundles running between the main ring and the carpellary supply throughout the length of flower. This, however, could not be made out in my material of *O. arborea.*

Anther.—A number of archesporial cells differentiate in the hypodermal layer of each lobe of the anther. A periclinal division of the archesporial tissue gives rise to the parietal layer and the sporogenous tissue in the usual way. As a result of further periclinal divisions of the primary parietal tissue, two layers are formed, of which the inner differentiates as tapetum (Fig. 116), while the outer divides further to form a middle layer and the endothecium (Fig. 117). Thus the wall of a fully formed anther is composed of a thin walled epidermis, a large celled endothecium, one middle layer, and one layer of tapetum in early stages. In older anthers two or even three layers of tapetum are found at places.

The cells of the middle layer degenerate early during the expansion of the anther (Fig. 118). Schaeppi and Steindl (1937, P. 387), describing the anther wall of *O. alba* write "Gegen die Antherenaussenwand hin findet man noch einzelne spindelformige Zellen als Uberreste der verdrangten Schicht." A reference to their figure 9a (p. 388) will clearly show that these cells represent the degenerating middle layer.

The epidermal cells are elongated and thin walled and show signs of early degeneration. In doing so their cells shrivel and are piled up into heaps to form several large round globules, which appear to be of an oily nature. These globules are deposited on the outer surface of the endothecial cells, where they can be made out even in a mature anther (Fig. 119). Though Schaeppi and Steindl's (1937) figure 9a shows that the epidermis has degenerated quite early when the microspore mother cells are just undergoing the reduction division, there is, however, no indication of any oily globules as found in the present material of *O. arborea.*

The endothecial cells, which are large and almost isodiametric in the beginning (Fig. 117), undergo considerable elongation in later stages (Figs. 118, 119), which is more pronounced in the region of the anther destined to form a beak (Fig. 118, 120).



TEXT FIGS. 116-124, Stages in microsporogenesis and the development of the male gametophyte of *O. arborea.*

Fig. 116, l.s. anther lobe showing the male sporogenous tissue and the formation of the wall layers. Fig. 117. l.s. anther with microspore mother cells and wall layers. Fig. 118, l.s. anther lobe with dividing microspore mother cells. Note the extreme elongation of some of the endothecial cells to form a beak like structure (also shown in Fig. 120); degenerating middle layer; two to three layers of uni-nucleate tapetum (*t*) with some of the cells of the innermost layer protruding between the microspore mother cells. Fig. 119, l.s. anther lobe with uni-nucleate pollen grains. Note the oily globules deposited on the outer surface of the endothecium after the degeneration of the epidermis; tapetum (*t*) degenerating *in situ*. Fig. 120, l.s. anther showing a lateral beak like structure (formed by extreme elongation of endothecial cells in this region, as shown in Fig. 118). Fig. 121, a tetranucleate mother cell. Note the formation of secondary spindles. (Only three nuclei are visible in this focus). Fig. 122, a tetrahedral tetrad of microspores. Fig. 123, a young microspore with vacuolate cytoplasm. Fig 124, an uni-nucleate pollen grain. Figs. 116, 117, × 475 ; figs. 118, 119, × 340; fig. 120, × 110; figs. 120-124, × 600

The endothecial cells develop very feeble fibrous thickenings by the time pollen grains have been formed in the anther (Fig. 119). As viable pollen grains are not formed in these flowers, the anthers usually do not dehisce and, therefore, the endothecial layer remains intact throughout.

The tapetal cells are characterised by the presence of a darkly stained dense cytoplasm. In contrast to the condition found in *Santalum* and *Thesium* species, the tapetal cells in *O. arborea* remain uninucleate throughout their life (Figs. 117, 118 *t*). Though in initial stages there is only one layer of tapetal cells, in later stages two to three layers may be observed (Fig. 118). The cells of the inner layer become elongated and protrude between the dividing microspore mother cells. During the development of the pollen grains the tapetal cells show distinct signs of degeneration *in situ*, and can be made out in this condition even in the oldest stage of the anther (Fig. 119 *t*).

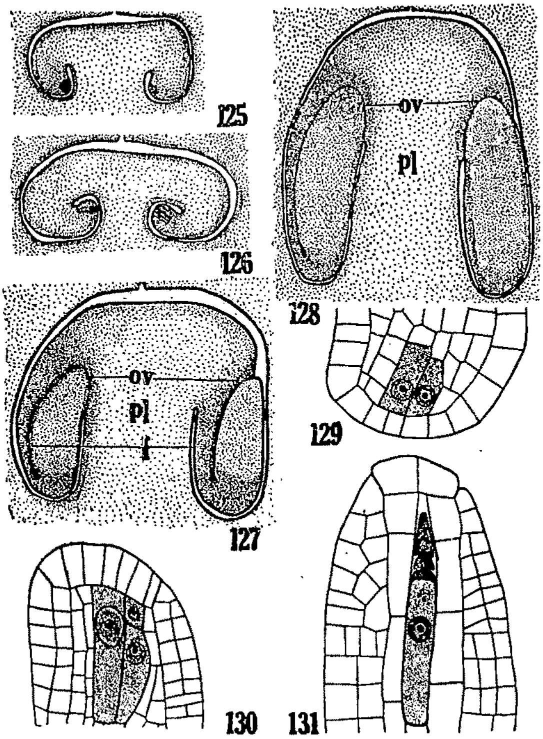
Microsporogenesis and development of the male gametophyte.—The sporogenous tissue divides in all planes to form a large number of polygonal microspore mother cells compactly arranged in each anther lobe (Fig. 117). They soon enter upon the reduction division and, before the heterotypic division is completed a mucilagenous wall is formed around each mother cell, which has now rounded up and freed from others (Fig. 118). The homotypic division of both the nuclei of the dyad results in the formation of a tetranucleate cell (Fig. 121). The wall formation takes place simultaneouly giving rise to tetrahedral microspore tetrads (Fig. 122).

In some cases the microspore tetrads start degeneration soon after they are formed and the further development of the anther is stopped. But usually the microspores separate from the mother cell wall and also enlarge (Fig. 123) and later their walls get thickened (Fig. 124). But in contrast to the usual condition the microspores show a highly vacuolate cytoplasm. They develop upto the uni-nucleate pollen grain stage only, when due to wholesale degeneration not even a single functional and viable pollen grain is discernable in anthers., A fully developed anther usually shows its loculi completely filled with shrivelled uninucleate pollen grains. In *O. alba* also a complete degeneration of pollen grains has been reported by Schaeppi and Steindl (1937). Such flowers of *O. alba* should be called male-sterile like those found in the present species.

It is interesting to note that in the male-sterile flowers of *O. arborea* no glandular hairs develop at the perianth lobes. These hairs are, on the other hand, present as regular feature in the male flowers of *Osyris* species. It is probable that these glandular hairs may be having some relation with the fertility and normal development of the pollen grains.

Development of the ovule.—Three ovular primordia develop laterally from thick hemispherical head of the placenta. Their growth is directed downward in the beginning (Fig. 125). On reaching the base of the ovary cavity, however, the ovular tip turns at right angle and begins to grow upward

(Fig. 126). A long funiculus is formed and the ovule grows quite up in the ovary cavity. At maturity, therefore, the ovule along with its funiculus, is 'U' shaped; the funiculus forming one arm of 'U', and ovule the other (Fig. 127). The different positions in which the ovules may lie in relation to the placenta and ovary wall, have been shown in figures 127 and 128. Due to a very limited space in the ovary cavity the ovule becomes hard pressed against the



TEXT Figs. 125-131, Stages in the development of the ovule, and megasporogenesis in *O. arborea.* (*f*, funiculus; *ov*, ovule; *pl*, placenta)

Fig. 125, l.s. ovary showing the ovule primordia directed downward at female archesporial cells stage. Fig. 126, l.s. ovary with ovules curving upward at megaspore mother cell stage. Figs. 127 & 128, l.s. ovary showing well developed ovules pointing up. Note the different positions of the ovules in relation to the placenta and the ovary wall.

Fig. 129, l.s. ovule with female archesporial cells. Fig. 130, l.s. ovule with megaspore mother cells. Fig. 131, l.s. ovule with tetrad of megaspores. Note in this figure, as well as in 130, the lateral small celled integumentary tissue distinct from the elongated nucellar cells enveloping the magaspore mother cells or tetrad of megaspores. Figs. 125-128, × 90; Figs. 129-131, × 400.

funiculus and the placental stalk, the cavity being completely filled with them (Fig. 128).

At the time of differentiation of the female archesporial cells the lateral part of the ovule is composed of more or less homogenous mass with no differentiation into nucellar or integumentary tissue (Fig. 129). Later two layers of small celled tissue formed by the divisions of the ovular epidermis, lying laterally to the megaspore mother cells, mark the differentiation of the integument from the central nucellar tissue (Fig. 130). This difference becomes clearly more marked at megaspore tetrad stage (Fig. 131). In *O. arborea,* just as in *Santalum,* the integumentary tissue does not grow beyond the level of nucellus and remains fused with it. Hence no micropyle is formed.

The difference between the nucellar and the integumentary tissue remains apparent upto young four-nucleate embryo sac stage. After this the nucellar tissue is crushed by the enlargement of the embryo sac. The greater bulk of the upper part of the integument is also crushed in later stage by the broadening of the tip of the mature embryo sac. Ultimately all the remaining tissue of the ovule also disappears during the development of the endosperm which comes to lie in direct contact with the ovary wall.

Megasporogenesis.—A number of archesporial cells differentiate in the young ovule when it is pointing downward in the ovary (Fig. 129). Usually one to four archesporial cells enlarge and are directly transformed into megaspore mother cells. Though generally only hypodermal cells take up the sporogenous character sometimes the sub-hypodermal cell may also elongate and become megaspore mother cell (Fig. 130). Schaeppi and Steindl (1937) have reported in *O. alba* that hypodermal archesporial cell directly functions as megaspore mother cell.

Usually only one megaspore mother cell develops further and undergoes the heterotypic changes, but quite frequently two to three mother cells may continue their development to form as many tetrads and embryo sacs. Both the meiotic divisions of a mother cell follow in quick succession and result in the formation of linear tetrad of megaspores, of which the chalazal member is functional and the upper three degenerate (Fig. 131).

Guignard (1885) who also believes that the archesporial cells directly function as megaspore mother cells in *O. alba,* has made a very peculiar statement about the further development of the megaspore mother cells and the formation of tetrads of megaspores. He writes "Elle se partage d'abord en deux cellules inégales, dont la supérieure forme une calotte, l'a inférieure se divise en trois et évolue comme dans le *Thesium.*" His figure, however, shows only two degenerated cells capping the functional megaspore. The present author feels that the case described by Guignard appears to be one in which a sub-hypodermal megaspore mother cell has undergone reduction division. Of the two dyad cells formed the upper one did not divide further and degenerated, while the lower divided further to form two megaspores. Schaeppi and Steindl (1937) have only cited Guignard's observations and have made no comments about their own observations. They, however, appear to believe that a linear tetrad of megaspores is formed and the development of the embryo sac is normal.

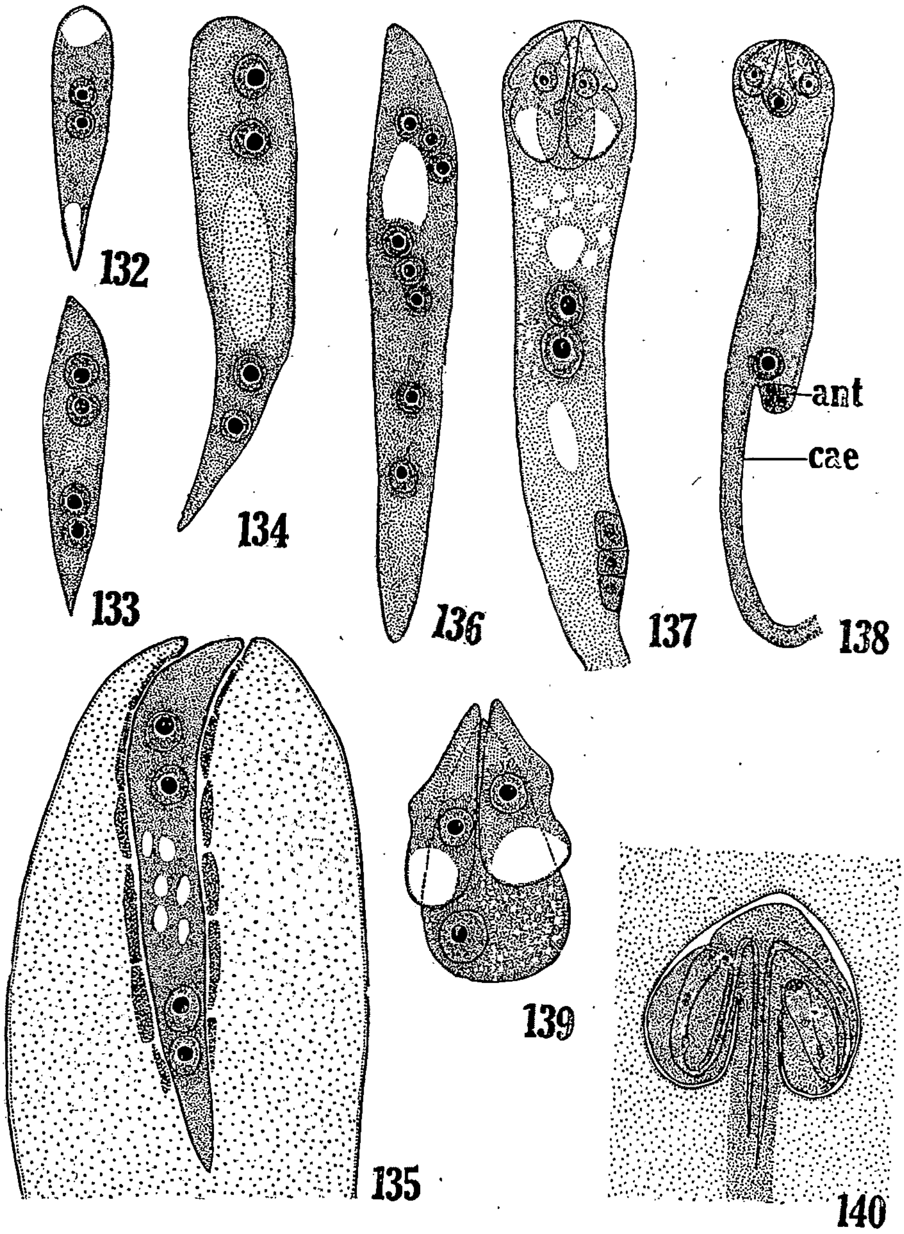
Development of the female gametophyte.—As already said the chalazl megaspore elongates and functions to form a monosporic embryo sac. Two- and four-nucleate embryo sacs are formed in the normal way (Figs. 132, 133). Somewhat similar to the condition found in *Santalum*, the embryo sac starts elongation at four-nucleate stage, but the extent of elongation is much less. Figs. 133 and 134 show two excised four-nucleate embryo sacs prior to and after elongation. In a few cases only the micropylar tip of the four-nucleate embryo sac crushes the tip of the ovule (Fig. 135), but does not grow beyond it.

The third division takes place simultaneously in both the micropylar as well as the chalazal pair of nuclei to form an eight nucleate embryo sac. Fig. 136 shows an eight nucleate embryo sac in which one nucleus from the micropylar quartet has moved down to lie near the nuclei of the chalazal quartet. Two nuclei destined to form antipodals are seen moving lower down in the embryo sac while the third antipodal nucleus is yet lying near the polar nuclei.

Mature embryo sac.—The mature embryo sac consists of an egg apparatus organised at the micropylar end, the polar nuclei lying hard-pressed with each other in the centre, and the antipodal cells organised towards the chalazal end of the sac (Fig. 137). The synergids are prominently beaked and show a filiform apparatus at the upper end. They have a vacuole at the lower end with the nucleus lying above it. The egg is pear shaped and is full of finely vacuolated cytoplasm having the nucleus at the base (Fig. 139).

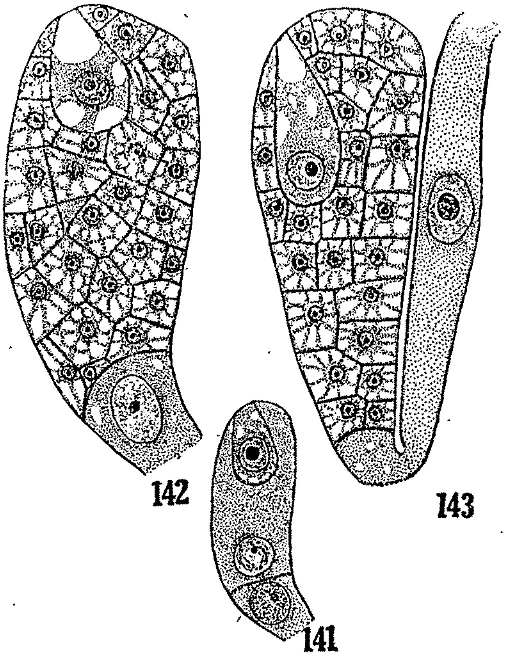
A lateral caecum, the chalazal embryo sac haustorium, arises from the embryo sac just by the side of the antipodals, which are left *in situ* in a small pouch (Figs. 137, 138). The caecum pierces through the tissue of the ovule to grow up in the funiculus. Ultimately it enters the placenta and grows down destroying the cells in its path. The activity of this caecum is much accelerated in post-fertilization stages when it grows deep down in the solid portion below the base of the ovary cavity (Fig. 140). The mature embryo sac thus has the shape somewhat like 'N' or depending upon the direction along which the ovule has bent (Fig. 140). The micropylar end of the embryo sac becomes considerably swollen, crushes the tip of the ovule and lies out of it.

Endosperm.—The first division of the primary endosperm nucleus is always followed by the formation of a cell wall which divides the embryo sac in an anterior and a posterior compartment (Fig. 141). The nucleus in the lower or posterior cell does not divide further but functions as the chalazal endosperm haustorial nucleus. It gets considerably enlarged and, though for some time it may remain at the same place where it was formed (Figs. 141, 142), it usually migrates deep into the haustorium and lies in the funicular region (Fig. 143).



Text Figs. 132-140, Stages in the development of the embryo sac of *O. arborea.* (*ant*, antipodals; *cae*, chalazal caecum).

Fig. 132, l.s. bi-nucleate embryo sac. Figs. 133 & 134, excised four-nucleate embryo sacs before and after elongation. Fig. 135, l.s. ovule showing an elongated four-nucleate embryo sac. Note the epidermal cells of the nucellus have been crushed by the tip of the embryo sac. Fig. 136, l.s. eight-nucleate embryo sac. One of the nuclei of the micropylar quartet has moved down to lie near the lower polar nucleus. Fig. 137, l.s. upper part of the mature embryo sac. Note the antipodal cells are left *in situ* as the chalazal caecum develops. Fig. 138, whole mount of the excised mature embryo sac. Note



TEXT FIGS. 141-143, Stages in the development of the endosperm of *O. arborea*.

Fig. 141, l.s. part of the embryo sac, after the first division of the primary endosperm nucleus, resulting in the formation of an anterior and a posterior compartment. Fig. 142, l.s. embryo sac with cellular endosperm, and the undivided zygote surrounded by the endosperm cells; the chalazal endosperm haustorial nucleus is lying at the mouth of the haustorium. Fig. 143, same as above but with the haustorial nucleus migrated deep in the haustorium. Note the considerably elongated zygote embedded in the endosperm. Fig. 141, × 475; figs. 142 & 143, × 340.

The chalazal caecum becomes very much aggressive under the influence of this haustorial nucleus. It grows rapidly devastating the tissue below the base of the ovary cavity for a considerable depth, following the course of the differentiated strand in this region.

The endosperm is formed in the anterior (micropylar) compartment only and is cellular. It soon becomes massive and, after crushing the tissue of the ovule and placenta completely, fills up the entire ovary cavity.

The zygote becomes considerably elongated and undergoes a very long period of rest. In the oldest flower that was available in the material with me, the development of the embryo had not started.

Thesium spp.

Three species of *Thesium*—*T. alpinum*, *T. humifusum* and *T. rostratum*, have been studied.

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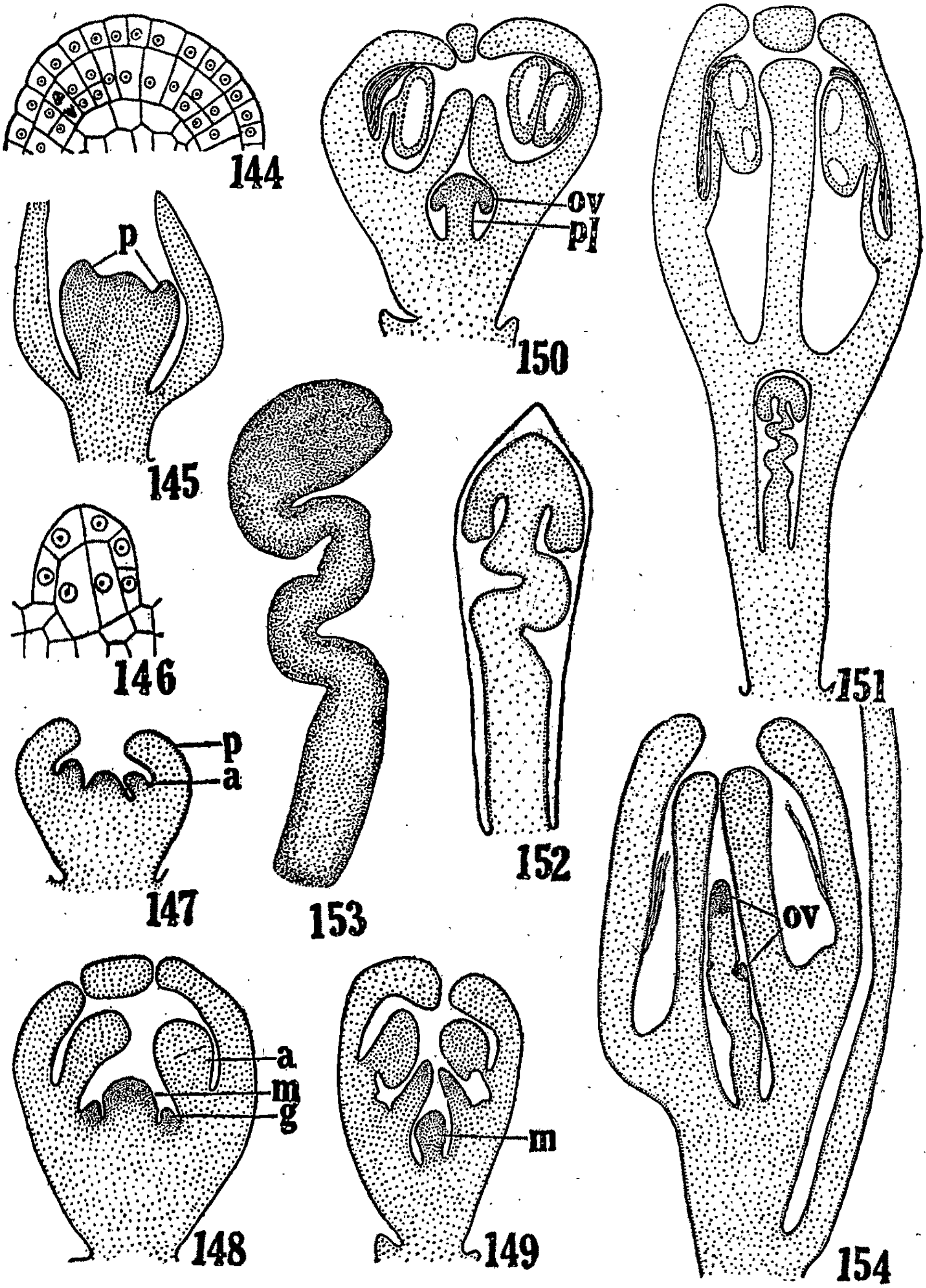
the laterally developed chalazal caecum, and the antipodal cells situated in a small pouch. Fig. 139, l.s. egg apparatus; the synergids are beaked and have a filiform apparatus at their tips. Fig. 140, diagram showing the position of the mature embryo sacs in the ovary. Figs. 132 & 135, × 400; figs. 133 & 134, × 270; figs. 136 & 137, × 380; fig. 138 × 200; fig. 139, × 460.



TEXT FIGS. 144-154, Showing the organogeny and morphology of the flower—*Thesium*. (Figs. 144-151& 154. *T. humifusum;* fig. 152, *T. alpinum;* fig. 153, *T. rostratum*). (*a*, androecium; *g*, gynaeceum; *m*, mamelon; *ov*, ovule; *p*, perianth; *pl*, placenta)
Fig. 144, l.s. floral apex just prior to the differentiation of perianth primordia.

Organogeny of the flower.—The first sign of a flower appears as a convex torus, which, in longitudinal sections, shows its two peripheral layers clearly differentiated from the remaining tissue forming the central core. The hypodermal layer of the torus shows pronounced activity in the form of periclinal divisions in its lateral flanks (Fig. 144), resulting in the establishment of perianth primordia (Fig. 145 *p*). The stamen primordia arise next which are also initiated from the second layer (Figs. 146, 147 a). The primordia of the ovary wall arise laterally on the surface of the torus in the end (Fig. 148 *g*), while the central convex projection of the torus, made up of five to six layers of cells, becomes the mamelon primordium (Fig. 148 *m*).

The ovary wall grows up enarching over the surface of the mamelon primordium. Soon the apical growth of the flower is stopped and the growth points are shifted to lateral positions. This results in the flanks of the receptacle growing vigorously, pushing the perianth, stamens, and the roof of the ovary upward. The mamelon is thus left at the bottom of the resultant cup (Figs. 149 *m*, 150).

Near the apex of the young placenta differentiate three ovular primordia, which originate only from two of the peripheral layers of the placenta. The fused bases of these three ovules form a conical tip of the mamelon (Fig. 150). The placenta elongates considerably due to the basal and intercalary growth followed by an extreme elongation of its cells. It is also accompanied by its slight thickening. Ultimately its upper half part gets contorted to accommodate itself in the limited space of the ovary cavity (Figs. 151, 152).

Morphology of the flower.—The flowers are hermaphrodite, pedicellate, the pedicel being two to three times longer than the flower. *T. humifusum* has very small flowers, which are more or less spherical in the bud condition, each flower being subtended by one large leafy, lanceolate bract and two similar but small bracteoles. *T. alpinum* and *T. rostratum* have considerably larger flowers which are elongated from the very beginning. The former has one large leafy bract and two bracteoles, whereas the latter has only one bract.

The gamophyllous perianth is persistent and consists of four or five lanceolate lobes, dissected half way. A lobe consists of three to four layers of mesophyll tissue enveloped by a single layer of epidermis. The epidermal cells on

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Fig. 145, l.s. flower bud showing the perianth primordia. Fig. 146, l.s. anther primordium. Fig. 147. l.s. flower bud at the time of differentiation of the androecium primordia. Fig. 148, l.s. an older flower bud showing the differentiation of the gynaeceum and mamelon primordia. Figs. 149 & 150, l.s. still older flower buds showing the development of the ovary and the mamelon. Fig. 151, l.s. fully formed flower bud. Fig. 152, l.s. mamelon showing pendulous ovules on the top of long and contorted free-central placenta. Fig. 153, whole mount of an abnormal mamelon showing only one ovule developed at the tip of the placenta. Fig. 154, l.s. abnormal flower of *T. humifusum*, with the placenta extended into the stylar canal; two ovules are seen differentiated at different places on the placenta. Fig. 144, × 490; fig. 146, × 600; figs. 145, 147, 148, × 130; figs. 149, 150, 154, × 60; fig. 151, × 30; fig. 152 × 80 fig. 153, × 150.

the outer surface of the perianth lobes are tangentially elongated and thick walled, while those of the inner surface are elongated into pointed hairs of variable length. In the upper part of the lobe they are quite small and represent a serrate structure. The hairs near the bases of the epiphyllous stamens are, on the other hand, very long and have a quite conspicuous nucleus each at their considerably swollen bases. As is the condition in *Santalum*, in *Thesium* spp. also these elongated hairs grow along the filament and completely arch over the anther (Fig. 151). The vascular supply of the perianth lobes usually runs in contact with the swollen bases of these hairs. Stamens are four to five, dorsifixed and have a long filament with a thick connective.

The ovary is completely inferior, tricarpellary, syncarpous, unilocular, and bears three unitegmic ovules laterally on the tip of a long and contorted placenta. When viewed from side only two ovules are visible. Their fused bases form a conical tip, which along with the placenta, gives the mamelon a typical arrow-head appearance (Fig. 152). Rarely, however, only one ovule may be differentiated on the top of the placenta and may be directed upward (Fig. 153).

The style is long, flattened and solid, without any stylar canal (Fig. 151). The globular stigma shows a characteristic papillate layer. In *T. alpinum* and *T. humifusum* it forms stiff and pointed hairs. Such hairs are also formed by the elongation of the epidermal cells in the upper part of the style.

Abnormal flowers.—*T. humifusum* material, obtained from Cambridge, contained two or three female flowers with comparatively shorter and thicker style (Fig. 154). The basal part of these flowers was greatly reduced. The style showed the presence of a wide and open canal, with nearly upper half of the placenta extending into it (Fig. 154). Two to three ovules, which differentiated on it at different levels in the stylar region, were directed upward. The uppermost ovule lay at the apex of the placenta. In one case one of these ovules in a lateral position had developed up to dyad stage, while the terminal ovule had advanced up to functioning megaspore stage. No anthers were present in these flowers and the glandular hairs were also only poorly developed. In *T. alpinum* also some abnormal flowers were observed, which showed a condition of gynaeceum intermediate between the normal flowers and these flowers described above.

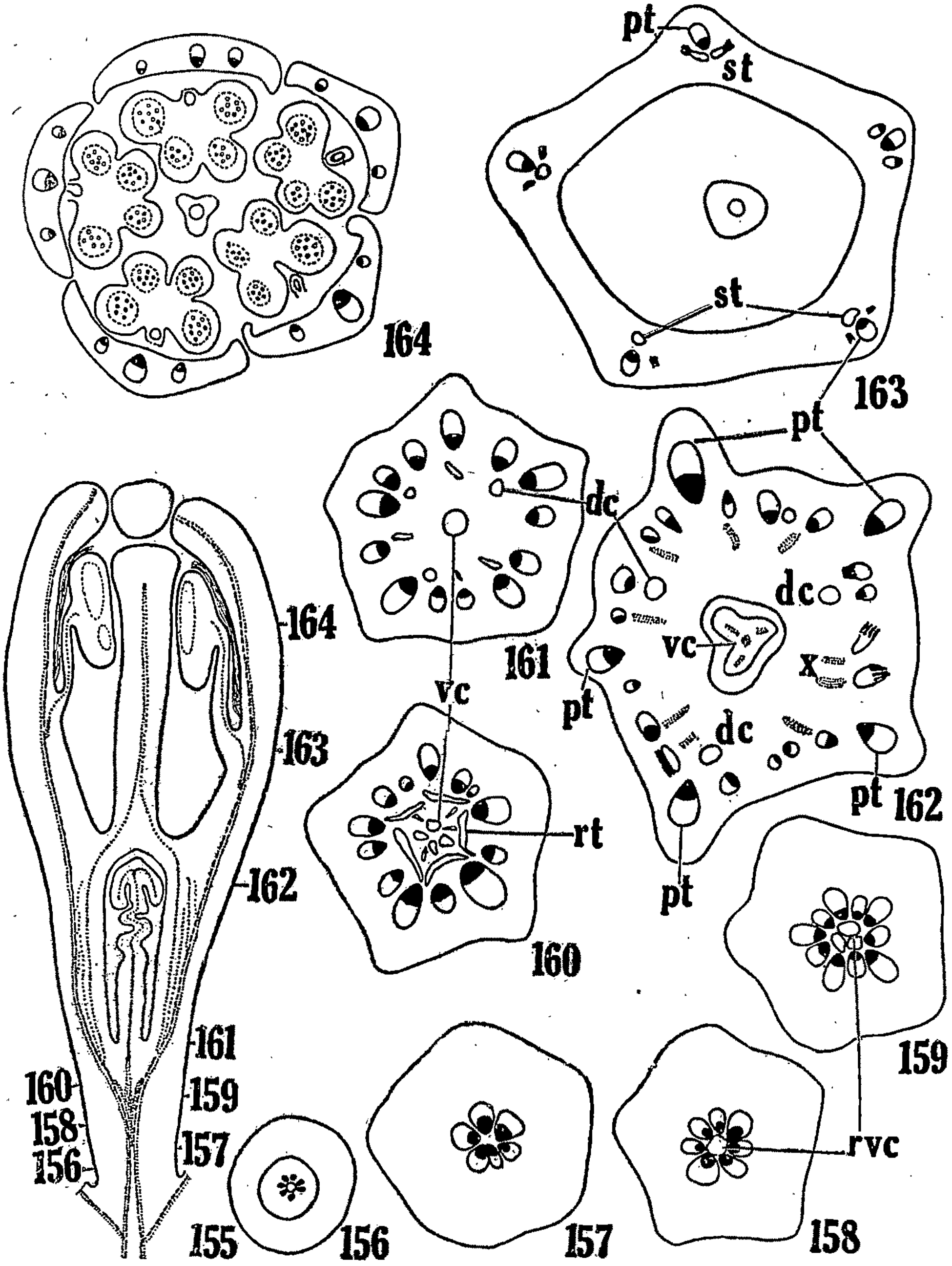
In *Vitis vinifera* var. *Mourvedre* (Baranov, 1927); *Stellaria media* (Pobedimova, 1929); *Beta vulgaris* (Archimovitch, 1931); *Gossypium* (Abraham, 1934); *Zelkowa crenata* (Finn, 1935); *Ulmus* (Leliveld, 1935) and *Holoptelea integrifolia* (Capoor, 1937) also abnormal ovules protruding into the open stylar canal, and even out of it, have been reported. These abnormalities have been attributed to be due to (a) some pathological phenomenon caused by some insect parasite (Finn, 1935); (b) vegetative mutations (Baranov, 1927); (c) genetic disturbances arising from hybridization (Abraham, 1934). Capoor (1937), also thinks that all the abnormalities of the ovule development in *Holoptelea* could not possibly be due to the mere pathological phenomenon of the insect larvae.

Vascular supply of the flower.—Index figures 155 and 165 show the longitudinal course of the vascular supply in *T. humifusum* and *T. alpinum* respectively. The numericals in the index figures represent the levels at which transverse sections of the same numbers have been drawn.

The pedicel of the flower shows three or four large collateral vascular bundles. These divide and increase in number as they move up. First of all the vascular supply to the bracts is separated (Fig. 155). The main vascular supply on entering the receptacle is represented as a compact cylinder of phloem investing five to seven groups of endarch xylem around a very small pith (Figs. 155, 156, 165, 166). In *T. humifusum* this compact cylinder soon breaks up into three or four large vascular bundles, which divide and increase in number to form a complete ring of bundles (Fig. 157). In *T. alpinum* also the phloem of the compact vascular cylinder shows forrowing (Fig. 167), but separate bundles are formed at a comparatively higher level.

At level 158 in *T. humifusum*, where the main vascular cylinder has broken up into separate bundles, and at level 167 in *T. alpinum*, where it is yet only furrowing, some vascular tissue appears in the pith region. In the former plant the central vascular tissue is mainly procambial, while in the latter this is mainly phloem, and fills the pith so completely that the main vascular supply seems to be composed of bicollateral vascular strands (Figs. 155, 165). Soon this phloem or procambial tissue occupying the pith region breaks up into three or four strands, and a small pith appears again (Figs. 159, 168 *rvc*). These separated stands of the centeral plate of vascular tissue soon show anastomoses with each other, and three to four branches arise from these which move obliquely inward and upward (Figs. 160, 169 *vc*). These branches soon fuse with each other to form a single compound strand (Figs. 155, 161, 165, 170, 171 *vc*), which enters the placenta as the ventral carpellary supply. After giving off the ventral carpellary supply the central phloem or procambial tissue swings obliquely out to merge completely with the main vascular supply (Figs. 155, 160, 165, 169). A perusal of the longitudinal course of the vascular supply in index figures and its comparison with the transverse sections clearly indicates that a few branches that arise from the main vascular ring undergo a down-ward course for a very short distance and then anastomose with each other to form a central plate of vascular tissue from which ventral carpellary supply moves in. The residue of these traces extends down in the pith compactly filling it and causes the main vascular ring to appear bicollateral for some distance in the base of the flower.

The ventral carpellary supply remains procambial for long in *T. humifusum*, whereas in *T. alpinum* it consists mainly of phloem. Some differentiated xylem tracheids can also be made out in the placental stalk in later stages of fruit development. Near the top of the placenta the ventral carpe-



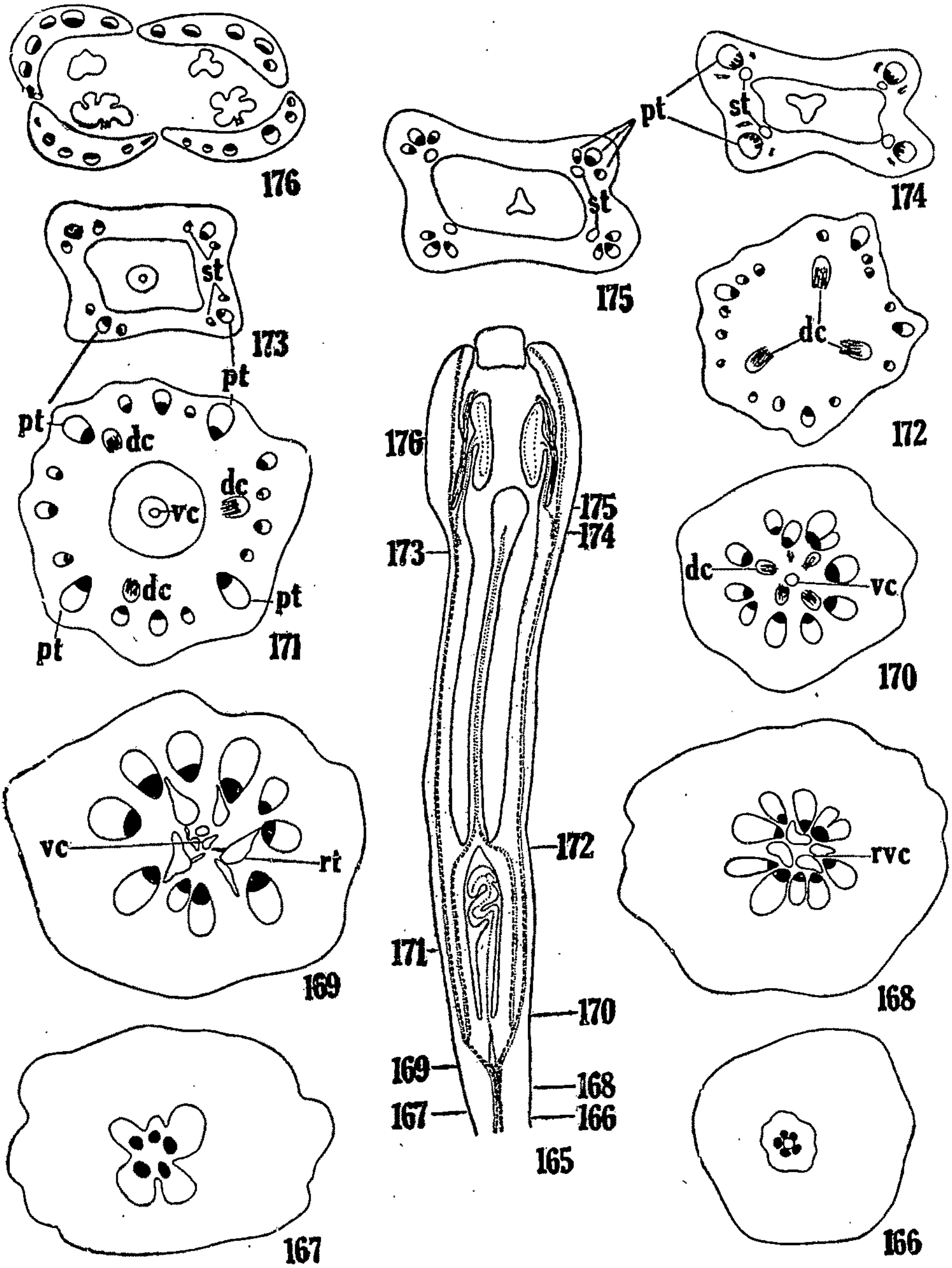
TEXT FIGS. 155-164 Showing the vascular supply of the flower of *T. humifusum.* (*dc*, dorsal carpellary supply; *pt*, perianth traces; *rt*, recurrent traces; *rvc*, residue of the ventral carpellary supply; *st*, staminal traces; *vc*, ventral carpellary supply; *X*, 'X' traces).

Fig. 155, diagram showing the longitudinal course of the vascular supply. Figs, 156-164, t.s. taken at levels marked in the index figure 155. Explanation in the text.

Fig. 155, × 30; figs. 156-162, × 45; figs. 163-164, × 30.

llary supply divides into three branches supplying the three ovules (Figs. 155, 162, 165).

Slightly below the base of the ovary cavity, the main vascular ring in



TEXT FIGS. 165—176, Showing the vascular supply of the flower of *T. alpinum* (Abbreviations same as in the previous plate.) Fig. 165, diagram showing the longitudinal course of the vascular supply. Figs. 166-176, t. s. taken at levels marked in the index figure 165. Explanation in the text. Fig. 165, ×20; figs. 166—169, ×40; figs. 170—176, ×25.

T. humifusum is seen to consist of five large collateral bundles (opposite to the raised portion), alternating with a large number of bundles between them (Fig. 161). A number of branches are separated towards inside from the smaller bundles. Three of these branch traces, which are stronger, represent the dorsal carpellary supply (Figs. 161, 162). The weaker branches, more of which are given off at higher levels from the smaller bundles of the main ring (Figs. 155, 162), travel for a short distance in the ovary wall and then end blindly. These traces have been called 'X' traces by Smith and Smith (1942 b). In *T. alpinum* also the dorsal carpellary supply is separated in the same fashion from the main ring (Figs. 165, 170, 171 *dc*), but the differentiation of the main ring into four large (*pt*) and a number of smaller bundles, alternating with them, becomes marked at a slightly higher level, when the dorsal carpellary supply has separated (Fig. 171).

In *T. humifusum* the dorsal carpellary supply remains procambial for long, whereas in *T. alpinum* it is very well differentiated. It is, however, considerably weakened by the time it reaches the top of the ovary. The vascular supply in the style is found to consist of very weak strands only.

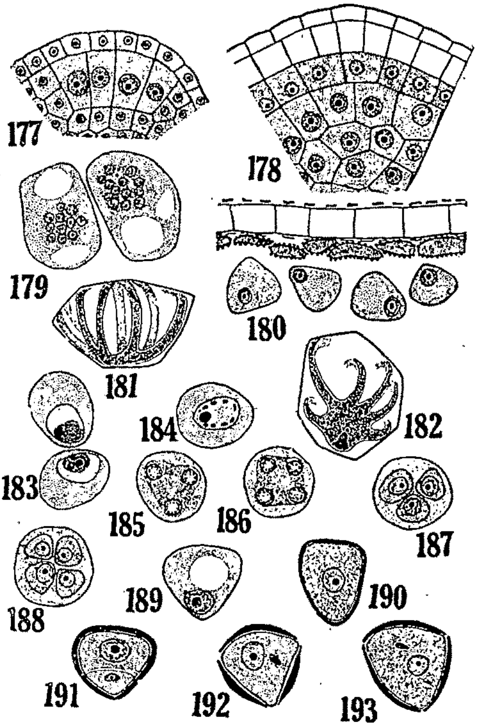
The large vascular bundles of the main ring (Figs. 162, 171 *pt*) continue upward undisturbed. An important change is noticed, however, in the smaller bundles, which lie alternating between the larger ones. These undergo a twisting of their axes to finally become inversely oriented (Figs. 162, 172). At the level the floral tube is freed from the ovary these inversely oriented bundles are considerably weakened and a number of them disappear, so that ultimately the vascular ring in the floral tube consists of only four or five large normally oriented bundles, with each of them having two lateral inversely oriented bundles (Fig. 173 *st*). These lateral bundles converge and come to lie opposite to the large bundles (Figs. 163, 174). During this process the xylem of the lateral bundles is left behind which soon disappears. The pairs of phloem strands thus left fuse to form a compound strand (*st*), lying against each of the large traces (*pt*) (Figs. 163, 174). The compound strands represent the staminal supply and enter the filament when it is freed from the perianth lobes.

The large normally oriented bundles represent the traces for the perianth. Each bundle divides into one median and two laterals (Figs. 164, 175), all of which enter the perianth lobes. In *T. humifusum* the number of these bundles does not increase further (Figs. 165), whereas in *T. alpinum* these divide further to give rise to five to six bundles in each perianth lobe (Fig. 176).

The vascular plan of the flower of *Thesium* described here is in general agreement with that described by Schaeppi (1942) on *T. alpinum* and *T. rostratum*. He is, however, silent about the presence of the central vascular tissue in the pith at the base of the flower, and the mode of origin of the ventral carpellary supply. The observations of Smith and Smith (1942 b) on the floral anatomy of *T. schumannianum* are also not very different from those presented here. The present author, however, does not agree with some of their interpretations, which have been taken up in "Discussion".

Anther—The first sign of an anther is seen in the form of a protuberance developed laterally on the torus. At this stage the longitudinal section of the primordium consists of an epidermis enveloping a single layer of elongated hypodermal cells, which undergo active divisions in all planes; followed by anticlinal divisions in the epidermis, so that the anther soon acquires a globular form.

The young globular anther soon becomes four-lobed. A number of archesporial cells differentiate in a row in the hypodermal layer of each lobe (Fig. 177). These cells divide periclinally in the usual way resulting in the formation of a primary parietal layer and sporogenous tissue. Further divi-



TEXT FIGS. 177—193, Stages in microsporogenesis and development of the male gametophyte in *Thesium*. (Figs. 177-181, 184-189, 191-192, *T. humifusum;* figs. 182-183, *T. rostratum;* figs. 190, 193, *T. alpinum.*)

Fig. 177, t. s. anther lobe with male archesporial tissue. Fig. 178, t. s. anther lobe showing the formation of wall layers and microspore mother cells. Fig. 179, multi-nucleate and enlarged tapetal cells. Fig. 180, l. s. anther lobe with uni-nucleate pollen grains. Note the remains of the degenerated epidermis and middle layer; tapetum is also degenerating. Figs. 181-182, whole mounts of endothecial cells showing characteristic stellate fibrous thickenings. Figs. 183—184, microspore mother cells in different stages of reduction division. Figs. 185-186 tetra-nucleate mother cells. Figs. 187-188, tetrahedral and isobilateral tetrads of microspores. Fig. 189, an enlarged microspore. Fig. 190, uni-nucleate pollen grain. Figs. 191-193, bi-celled pollen grains. Figs. 177-179, 183-193, ×900; fig. 180, ×680; figs. 181-182, ×750.

sions of the parietal cells give rise to two layers, of which the inner forms the tapetum (Fig. 178). The cells in the outer layer divide further to form a feeble middle layer, enveloped by a complete layer of cells, representing the endothecium. The cells of the middle layer are very ephemeral and degenerate soon after their formation.

The epidermal cells are tangentially elongated, thin walled (Fig. 178), and degenerate by the time the microspore tetrads are formed. The remains of the degenerated epidermal cells may, however, be seen upto the uninucleate pollen grain stage (Fig. 180).

The endothecial cells are also slightly tangentially elongated (Figs. 178, 180), and have a quite conspicuous nucleus suspended in the middle of the vacuolate cytoplasm. The endothecium remains in this condition upto the uni-nucleate pollen grain stage of the anther. Later the fibrous thickenings are developed in a very characteristic manner which are best studied in the surface view. The inner tangential wall of an endothecial cell develops a plate of thickening. Numerous branchs arise from the margins of this thickened plate and run along the radial walls, converging at the surface of the outer tangential wall. Thus the fibrous thickenings in a surface view present a striking stellate pattern (Figs. 181, 182). In Tulip and Buttercup a similar method of the development of fibrous thickenings has been described by Priestley and Scott (1950). In the former, however, the thickened plates are laid down on both inner as well as outer tangential walls connected by thickened arms running along the sides of the cells.

The tapetal cells, which have a dense cytoplasm, remain uni-nucleate upto the time the microspore mother cells enter upon the reduction division. Later the tapetal nuclei undergo a number of mitotic divisions so that the cells become multi-nucleate. Though five-to six-nucleate condition is most frequent, as many as ten to twelve nuclei may be seen in some of the cells (Fig. 179).

When the anther has developed to the microspore stage the tapetal cells show distinct signs of degeneration *in situ*, their cells shrivel up and the cytoplasm takes a dark stain (Fig. 180). Some dark globules are observed on the outer surface of the degenerated tapetal cells.* In an anther showing bicelled pollen grains no sign of the tapetum is ultimately left.

Microsporogenesis.—The primary sporogenous tissue undergoes a number of divisions in all planes to form a compact tissue of polygonal and thin walled microspore mother cells (Fig. 178). In longitudinal sections they appear to be arranged in three to four rows of cells. The microspore mother cells soon enter upon the reduction division and undergo the usual heterotypic changes (Figs. 183, 184). By this time their corners have rounded up and the cells are freed from one another. The nucleus is enlarged and occupies a considerable part of the cell cavity. A mucilagenous wall is formed around them which later becomes quite thick and hyaline (Figs. 185, 186)

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*It has been suggested that such dark globules present on the surface of tapetal cells take some part in the formation of the exine of the pollen grain (Ubisch, 1927; Kosmath, 1927; Kajale, 1940; Puri, 1941; Singh, 1950, 1952).

The first division of the microspore mother cells results in the formation of bi-nucleate cells. The homotypic division follows quickly to give rise to four-nucleate cells (Figs. 185, 186). Cytokinesis takes place simultaneously by furrowing of the cell wall followed by the wedging of the mucilagenous wall, as in *Santalum.* The tetrads of microspores exhibit a tetrahedral or an isobilateral arrangement (Figs. 187, 188).

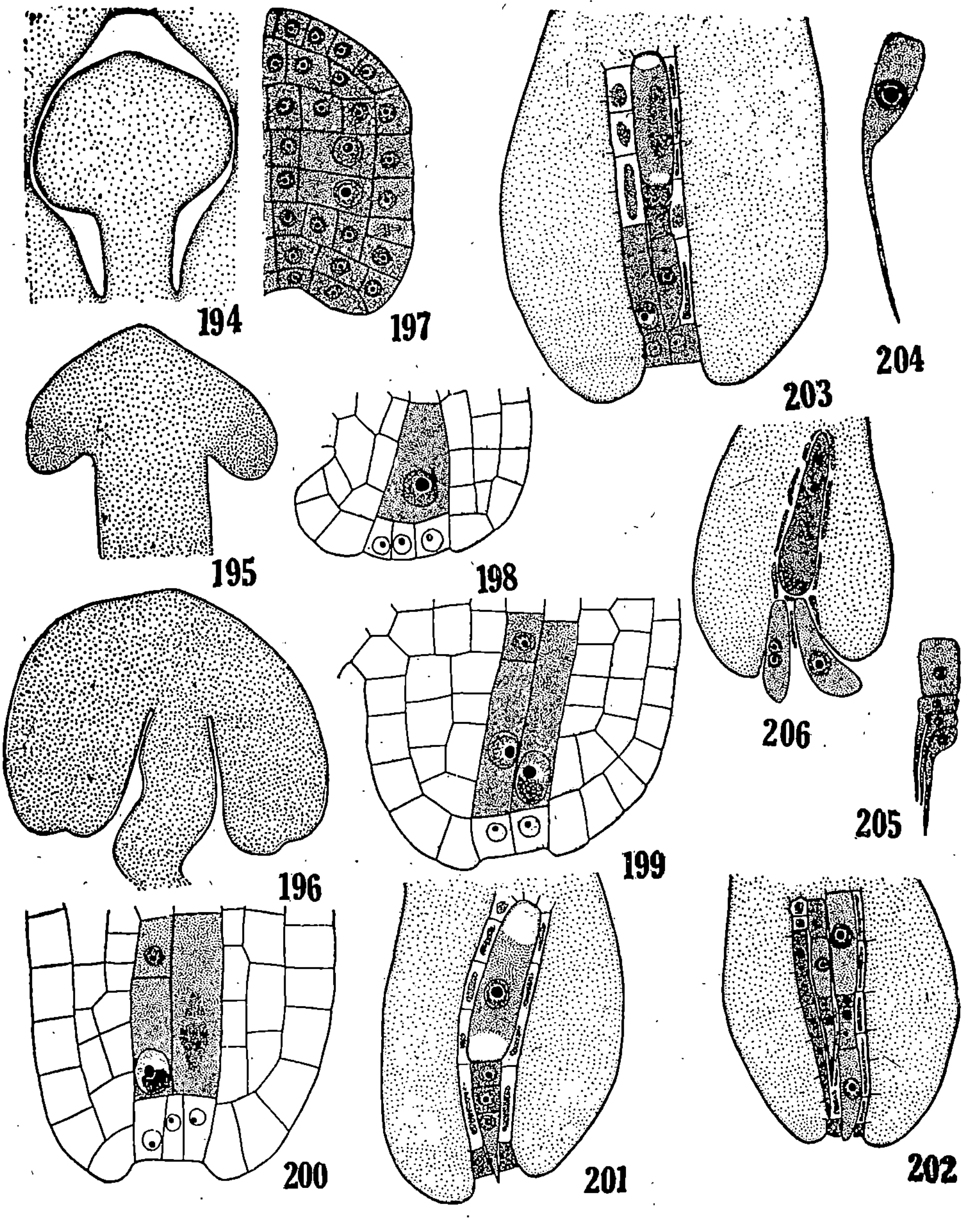
Development of the male gametophyte.—Young microspore is somewhat oval with the nucleus lying in the centre of the dense cytoplasm which is devoid of any conspicuous vacuolisation. As it enlarges a vacuole appears in the centre and the nucleus is shifted to the narrow end of the cell (Fig. 189). In *T. alpinum,* however, the nucleus usually remains in the centre of the cell which shows finely vacuolated cytoplasm (Fig. 190).

The wall of the microspore soon gets thickened. The division of the microspore nucleus takes place at this stage at the narrow end, to give rise to a small generative cell, cut off in the corner, and a large vegetative cell occupying the rest of the space (Fig. 191). The generative cell is soon detached from the wall of the pollen grain, surrounding itself with a thin sheath of hyaline cytoplasm, and moves to the centre of the pollen grain (Figs. 192, 193).

A mature pollen grain is triangular in outline and has a thin intine and a moderately thick exine with three germ pores (Figs. 192, 193). The exine of some of the mature pollen grains of *T. alpinum* was found to be slightly warty.

Ovules.—The differentiation of the ovule is marked as a lateral protuberance arising near the tip of the young placenta. The early growth of the ovular protuberance is directed at right angles to the placenta (Fig. 194), but due to more active divisions on the upper and outer side of the ovule, it begins to curve downward (Fig. 195). Ultimately the ovules become completely pendulous (Fig. 196) with their tips pointing down in the ovary cavity.

At the time of differentiation of archesporial cells, no integument can be clearly made out (Fig. 197). But in an ovule with megaspore mother cells the integumentary tissue appears laterally to them and bulges slightly above the nucellar epidermis capping the megaspore mother cell (Fig. 198). This bulging becomes quite marked in the ovules in which the megaspore mother cells are well elongated (Fig. 199) or have entered the reduction division (Fig. 200). In the ovules showing the development of the embryo sac (Figs. 203, 209, 210) the integumentary tissue has bulged sufficiently above the nucellar epidermis to form a small and rudimentary micropyle. It is probably because of the presence of this micropyle that the previous workers, namely Warming (1878), Schulle (1933), Rutishauser (1937), Rao (1942) have all shown the presence of an integument in different species of *Thesium* studied by them. The nucellus in *Thesium* species is comparatively narrow and almost whole of it is differentiated as sporogenous tissue. A considerable part of the integumentary tissue



TEXT FIGS. 194-206, Stages in the development of ovule, and megasporogenesis in *Thesium*. (Fig. 204, *T. rostratum;* fig. 205, *T. alpinum;* rest figs., *T. humifusum*).

Figs. 194-196, l. s. placenta and ovules in different stages of development. Fig. 197, l. s. young ovule with female archesporial cells. Fig. 198, l. s. ovule with young megaspore mother cell, (only one mother cell can be seen in this focus). Figs. 199, 200, l. s. ovules showing enlarged megaspore mother cells. Note the integumentary cells have started bulging over the nucellus. Fig. 201, l. s. ovule with tetrad of megaspores. Note the chalazal megaspore is functional while the micropylar one has also elongated to pierce through the nucellar epidermis into the micropyle. Fig. 202, l. s. ovule showing two tetrads of megaspores. In the left tetrad the is crushed during the development of the embryo sacs. The swollen micropylar tip of the mature embryo sac also crushes a greater part of the tip of the ovule. Ultimately whole of the ovule is crushed during the development of the endosperm, which lies free in the ovary cavity.

Of the three ovules present in an ovary, only one reaches the mature embryo sac stage, while the growth of the other two is stopped soon after they have reached the megaspore tetrad or young embryo sac stage. These non-functional ovules remain intact for a longer period, and are crushed quite late during the development of the fruit.

Megasporogenesis.—A multicellula archesporium differentiates in the hypodermal and also sub-hypodermal layers of the young ovule. As the sporogenous tissue is arranged in layers through the thickness of the ovule usually only two to three cells can be made out in one section (Fig. 197). In *T.humifusum* and *T. rostratum* almost all the cells of the nucellar region take up a sporogenous character. A number of hypodermal archesporial cells enlarge and directly function as megaspore mother cells. As parietal cells are not cut off, there is no wall layer capping the hypodermal megaspore mother cells (Figs. 198, 199, 200). This can be clearly observed only in perfectly median longitudinal sections, cut along the broad surface of the ovule. In oblique sections of an ovule, megaspore mother cells may appear to be capped by subepidermal layers. These do not form the wall layers but are the cells of the integument in immediate contact of the nucellus. Schulle (1933) and Rutishauser (1937) have also reported that the archesporial cells directly function as megaspore mother cells and no wall layers are formed.

Each megaspore mother cell is considerably elongated and has a conspicuous nucleus lying towards the micropylar end (Figs. 199, 200). There are four to five functional megaspore mother cells in *T. alpinum* and *T. humifusum*, while in *T. rostratum* six to eight megaspore mother cells develop further upto the tetrad of megaspores stage. A number of mother cells are arrested in growth, while others degenerate. Fig. 203 shows a megaspore mother cell in the synizesis stage, arrested in growth, whereas its sister cell has formed the megaspore tetrad. Rutishauser (1937) has also reported that in *T. rostratum* as many as nine megaspore mother cells are formed of which 4 or 5 develop to embryo sac stage. In *T. wightianum* on the other hand, only one or sometimes two megaspore mother cells are formed (Rao, 1942).

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second member from the chalazal end is functioning. In both tetrads the micropylar megaspore is also showing elongation. Fig. 203, 1. s. ovule showing the chalazal megaspore dividing, while the micropylar megaspore has also elongated. On the left is seen a megaspore mother cell arrested in growth. Fig. 204, whole mount of a megaspore haustorium. Fig. 205, a tetrad of megaspores of *T. alpinum* where the micropylar three megaspores have each developed a long tube like megaspore haustorium. Fig. 206, 1. s. ovule to show the micropylar megaspores elongating to protrude out of the ovule. One of them is bi-nucleate. Note that the embryo sac developed from the chalazal megaspore has degenerated.

Figs. 194-196, × 250. figs. 197-200, 203, × 660; figs. 201, 202, 204, 206, × 480; fig. 205, × 540.

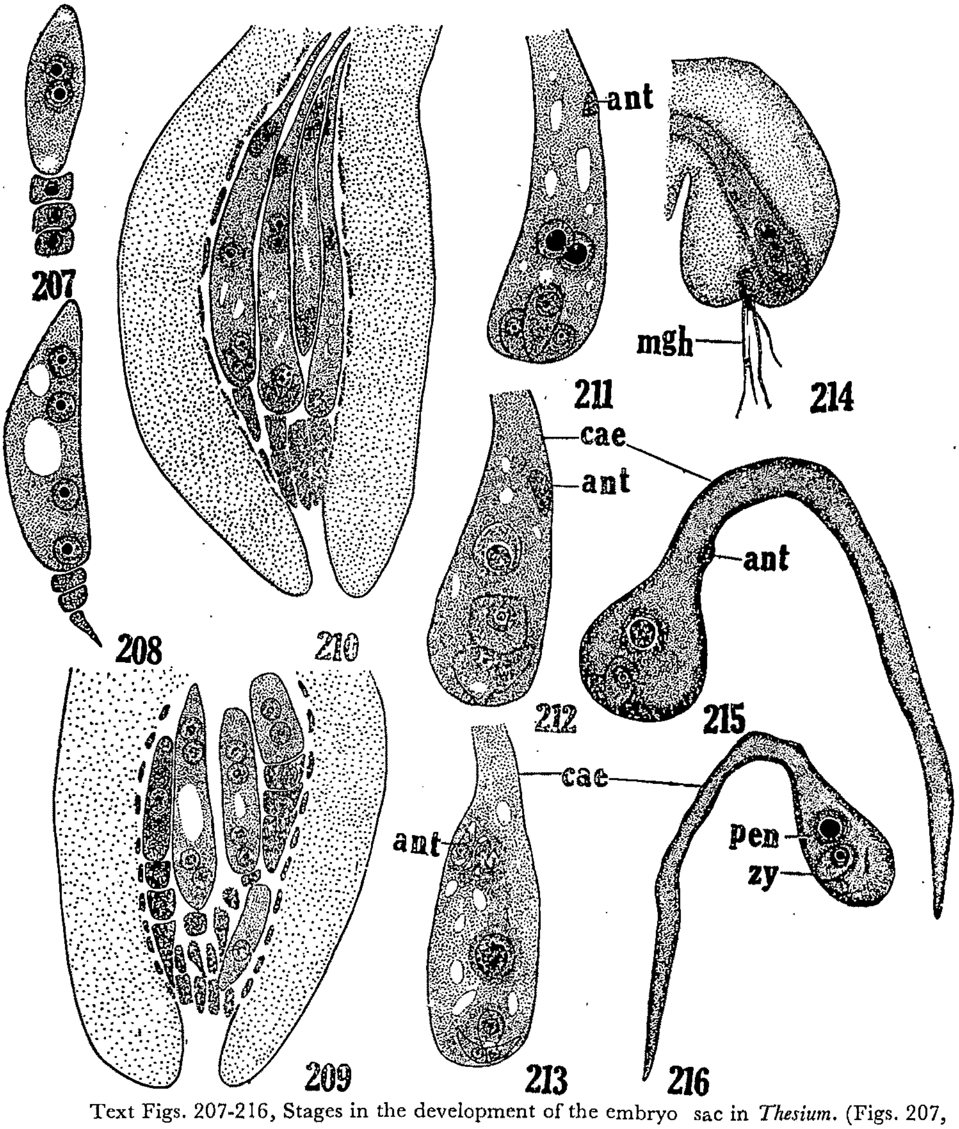
The heterotypic division of the megaspore mother cell (Fig. 200) results in the formation of dyad cells. It is quickly followed by the homotypic division in both the cells of a dyad, resulting in a linear row of four megaspores (Figs. 201, 202). Since many tetrads of megaspores are formed in each ovule, it is not possible to say definitely if 'T' shaped tetrads are also formed. Rutishauser (1937) reports, however, that in *T. rostratum,* though normally a linear tetrad of megaspores is formed, sometimes only two degenerating cells capping a developing embryo sac are observed. To explain this he writes (p. 37) "Ob in diesen Fallen eine nachtragliche Verschmelzung Zweier Makrosporen stattgefunden hat, oder of wirklich nur drei Makrosporen gebildet wurden, kann nicht mehr mit Sicherheit angegeben werden." In my opinion this is due to, in some cases, the second megaspore from the chalazal end functioning, so that only two degenerated cells are seen capping the functioning megaspore or the developing embryo sac.

Development of the female gametophyte.—Usually the chalazal and sometimes the second megaspore from the chalazal end of a tetrad of megaspores functions and develops to form a monosporic embryo sac. This is in agreement with the findings of Rutishauser (1937) on *T. rostratum.* In *T. divaricatum,* according to Guignard (1885), as a rule only three 'megaspores' are formed . Truly speaking only two of them can be megaspores while the third one is an undivided dyad cell. The embryo sac is formed by one of the megaspores and is, therefore, monosporic. The observations of Modilewski (1928) on *T. intermedium* and Schulle (1933) on *T. montanum* are, however, interesting. They have reported that the embryo sac is formed directly by three divisions of megaspore mother cell. Thus all the four megaspore nuclei take part in the formation of an embryo sac, which is therefore, tetrasporic and follows "*Lilium type*" ("*Adoxa type*" of Maheshwari, 1948, 50). This method of embryo sac formation in *Thesium* sp. is doubtful (see Discussion).

Megaspore haustoria.—It is interesting to find that the non-functional megaspores of the three species of *Thesium* described here persist for some time and show varied activity. In *T. humifusum* and *T. rostratum,* of the three non-functional megaspores, the lower two degenerate, while the uppermost (micropylar megaspore) develops a pointed tip and undergoes considerable enlargement (Figs. 201-204). Its tip pierces through the nucellar epidermis and projects out of the ovule. The megaspore nucleus may undergo one or two divisions and the cell forms a coenocytic haustorium (Figs. 204, 206). In one case in *T. alpinum* the three non-functional megaspores, situated above the functional one, had each developed a tube like megaspore haustorium, which grew upward gliding over the surface of other megaspores (Fig. 205).

In micro-dissections the megaspore haustoria are more clearly seen as very long, thin, membranous, tubular structures jutting out of the ovular tip and entering the placental tissue.

These haustoria may persist up to the mature embryo sac stage. It is interesting to find that the considerably swollen micropylar tip of the mature



Text Figs. 207-216, Stages in the development of the embryo sac in *Thesium*. (Figs. 207, 208, 211, 212, 214, *T. humifusum;* figs. 209, 210, 213, 216, *T. rostratum;* fig. 215, *T. alpinum.*) (*ant,* antipodals*; cae,* chalazal caecum*; mgh,* megaspore haustoria*; pen,* primary endosperm nucleus*; zy,* zygote).

Figs. 207, 208, l. s. bi-nucleate and four-nucleate embryo sacs respectively, capped by non-functional megaspores. Fig. 209, l. s. ovule showing all stages from a tetrad of megaspores to four-nucleate embryo sacs. Fig. 210, l. s. ovule showing an eight-nucleate and also organised embryo sacs. Figs. 211-213, parts of mature and organised embryo sacs. Note the antipodal cells left *in situ*, while the chalazal caecum grows. Fig. 214, whole mount of an ovule showing the mature embryo sac shifted to a lateral position, and the megaspore haustoria jutting out of the micropyle. Figs. 215, 216, whole mounts of excised mature and fertilized embryo sacs. Note the elongated chalazal caecum; the primary endosperm nucleus lying near the laterally placed zygote in fig. 216.

Figs. 207,208, x 600; figs. 209, 211-213, x 475; fig. 210, x 425; fig. 214, X 174; figs. 215, 216, x 240.

embryo sac occupies a lateral position in the ovule, (Fig. 214), so that the megaspore haustoria, which occupy mostly the micropylar region, are not destroyed by its growth.

Such megaspore haustoria have also been reported in *Galium lucidum* and some other members of Rubiaceae (Fagerlind, 1937). In *Sedum sempervivoides* and *Rosularia pallida* all the megaspores give out lateral tubes which subsequently begin to grow upward and come out of the micropyle (Mauritzon, 1933).

Development of the embryo sac.—Only one of the three ovules of a flower reaches the mature embryo sac stage, while in others a degenerated mass of megaspores or two-nucleate embryo sacs arrested in growth, can be made out. The number of mature embryo sacs in the fertile ovule varies in different species. In *T. alpinum* only one or sometimes two embryo sacs grow side by side, while in *T. humifusum* and *T. rostratum* the number may vary from four to six. Sometimes in the latter species the number of embryo sac may be found to be as high as eight or nine.

The first division of the megaspore nucleus results in the formation of a bi-nucleate embryo sac, whose nuclei may not show an early and definite polarisation (Figs. 207, 209). The second division follows quickly to form a four-nucleate embryo sac (Figs. 208, 209). Unlike *Santalum* and *Osyris*, the four-nucleate embryo sac in *Thesiom* species does not show any appreciable micropylar elongation, and remains confined to the ovule (Fig. 209).

The third division usually takes place simultaneously in both micropylar as well as chalazal pair of nuclei to form the respective quartets (Fig. 210, second embryo sac from right). Sometimes in *T. rostratum* and also in *T. humifusum* the chalazal pair of nuclei does not undego the last division. One of these nuclei directly functions as the lower polar while the other either degenerates soon or is organised into a single antipodal cell.

The development of all the embryo sacs in a fertile ovule is not synchronic. Thus all stages from a four-nucleate embryo sac arrested in growth to an organising eight-nucleate embryo sac may be seen in the same ovule. However, only one mature embryo sac is ultimately left, while others degenerate at different stages of growth. Thus out of about 12 megaspore mother cells of *T. alpinum* and *T. humifusum*, and 20 of *T. rostratum*, that are formed in three ovules of a flower, only two or three are able to reach the mature embryo sac stage, of which only one is ultimately fertilised and develops further. Rutishauser (1937, p. 38), who has also reported the same condition in *T. rostratum*, writes, "Nur ein einziger Embryosack jedes Fruchtknotens entwickelt sich somit weiter, sodass also von den über 20 Embryosackmutterzellen jeder Blüte nur eine ihrer Bestimmung zugeführt wird. Diese allen Santalaceen gemeinsame Eigenschfat stellt nach unserer Ansicht einen weiteren schritt zur Reduktion des Gynaceums darund dürfte letztlich zu Formen mit nur einer Samenlage führen."

Mature embryo sac.—The organisation of the mature embryo sac is quite normal. The antipodal nuclei of the chalazal quartet are the first to be organized into cells. As already said in some cases only one antipodal cell is organised due to the suppression of the last division in the chalazal pair of nuclei. The antipodal cells are, however, very ephemeral and degenerate quite early, sometimes even before the organisation of the egg apparatus has been completed. Rutishauser (1937) has also reported a quick and early degeneration of the antipodal cells in *T. rostratum.* Rao (1942) has on the other hand, reported that in *T. wightianum* the antipodal cells are quite persistent and can be seen adhering to one side of the embryo sac even after fertilization.

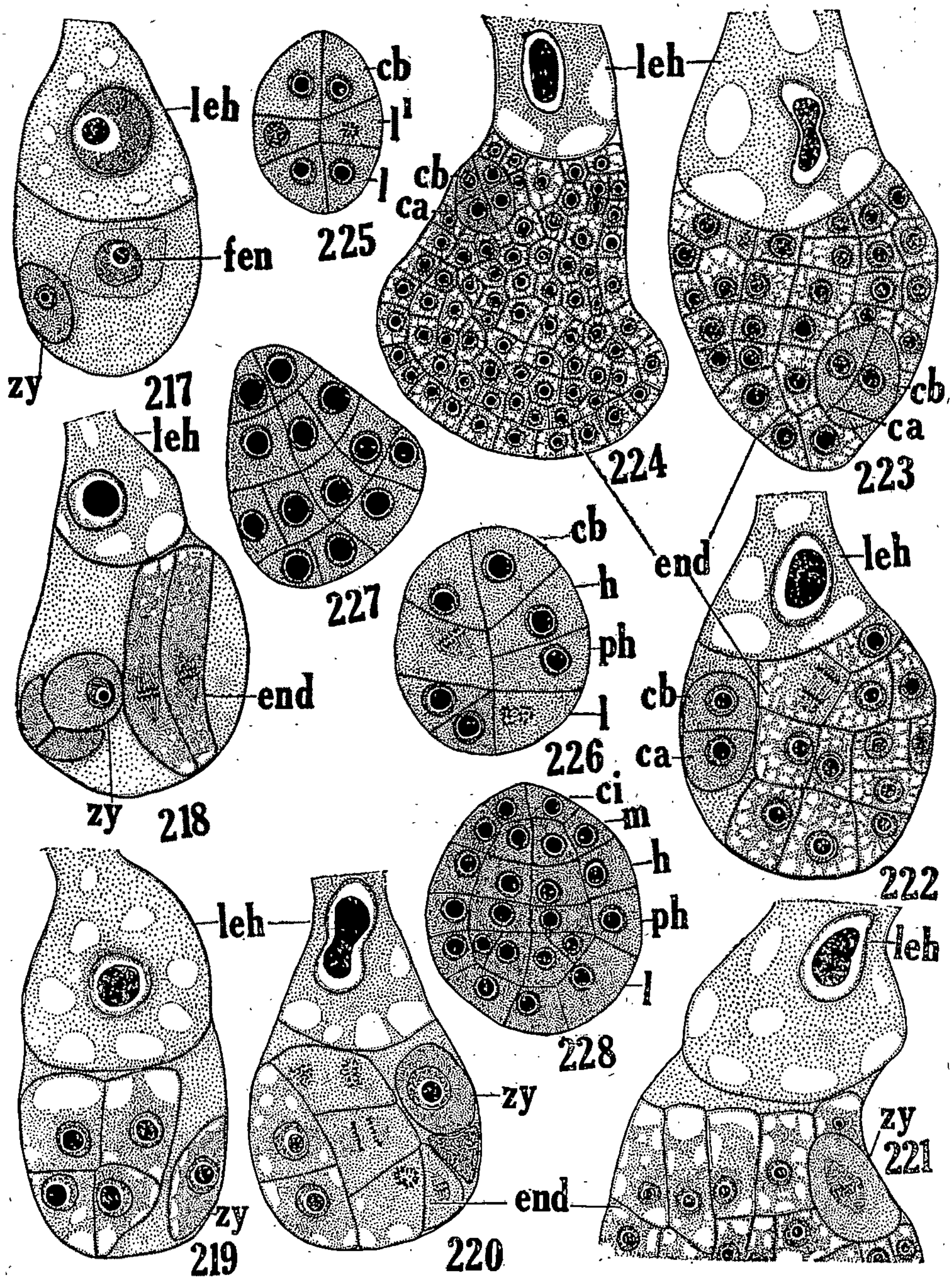
The lower polar nucleus ramains towards the chalazal end while the upper polar nucleus moves down, so that the two nuclei ultimately lie towards the chalazal part of the embryo sac, in a hard-pressed condition (Fig. 210, second embryo sac from left). Later both polar nuclei move up in the embryo sac where their fusion is completed. At the time of their formation the polar nuclei are almost of the same size as that of the other nuclei of the embryo sac. But both polar nuclei begin to increase in size as the upper polar nucleus moves down and by the time they fuse, they become considerably enlarged. The secondary nucleus, which is the most conspicuous component of the embryo sac because of its gigantic size, ultimately comes to lie very near the egg apparatus (Figs. 212-214).

The egg apparatus, consisting of two synergids and one egg cell, is organised a bit later. The synergids are quite small and do not show any filiform apparatus or beak as is seen in *Santalum* and *Osyris.* They are also comparatively ephemeral and degenerate soon after fertilization. A fertilised embryo sac thus shows only a laterally placed zygote and a gigantic primary endosperm nucleus lying very near the zygote (Fig. 216).

The micropylar end of the embryo sac, though does not show any appreciable growth in length, it undergoes a considerable broadening soon after the egg apperatus is organised. In doing so it is always shifted to a lateral position in the ovule, usually towards the outer side (Fig. 214). Due to the broadening of the head of the embryo sac the integumentary tissue lying above it and lateral to the micropyle, is crushed so that the swollen embryo sac head ultimately lies free in the ovary cavity. In *T. humifusum* the micropylar tip of the mature embryo sac in some cases is found to be flattened and in others a deep depression is seen in the centre of the top of the flattened head. In median longitudinal section this depression gives a bifid appearance to the micropylar end of the embryo sac, with the egg cell or zygote lying in one of the tips.

In embryo sacs showing such depression the synergids were seen either degenerating or had already degenerated and the polars had already fused. These embryo sacs were, therefore, fertilised. This depression which is present only in fertilised embryo sacs is presumably caused by the pollen tube during its penetration into the embryo sac.

Chalazal embryo sac haustorium.—Soon after the embryo sac has reached eight-nucleate stage, its chalazal end shows lateral elongation leaving the



TEXT FIGS. 217-228, Stages in development of endosperm and embryo of *Thesium*. (Figs. 224, 227, 228, *T. alpinum;* rest figs. *T. humifusum*) (end, endosperm; *zy*, zygote; *ca*, *cb*, *ci*, *h*, *l*, *l'*, *m*; *ph*; different tiers of embryo).

FIG. 217, l. s. embryo sac after the first division of the pirmary endosperm nucleus, with a posterior and an anterior compartment. Note the lateral position of the zygote. Fig. 218 ,l. s. embryo sac showing the development of the endosperm in the anterior compartment only.

antipodals *in situ* (*ant*) (Figs. 210-213). This caecum, the chalazal embryo sac haustorium (Figs. 212-216 *cae*), penetrates through the basal tissue of the ovule to enter the placenta, where it bends and grows downward following a course along the vascular supply. A mature embryo sac thus has the shape of an inverted 'U', but later with the further growth of the chalazal embryo sac haustorium it becomes inverted 'J' shaped (Figs. 215, 216).

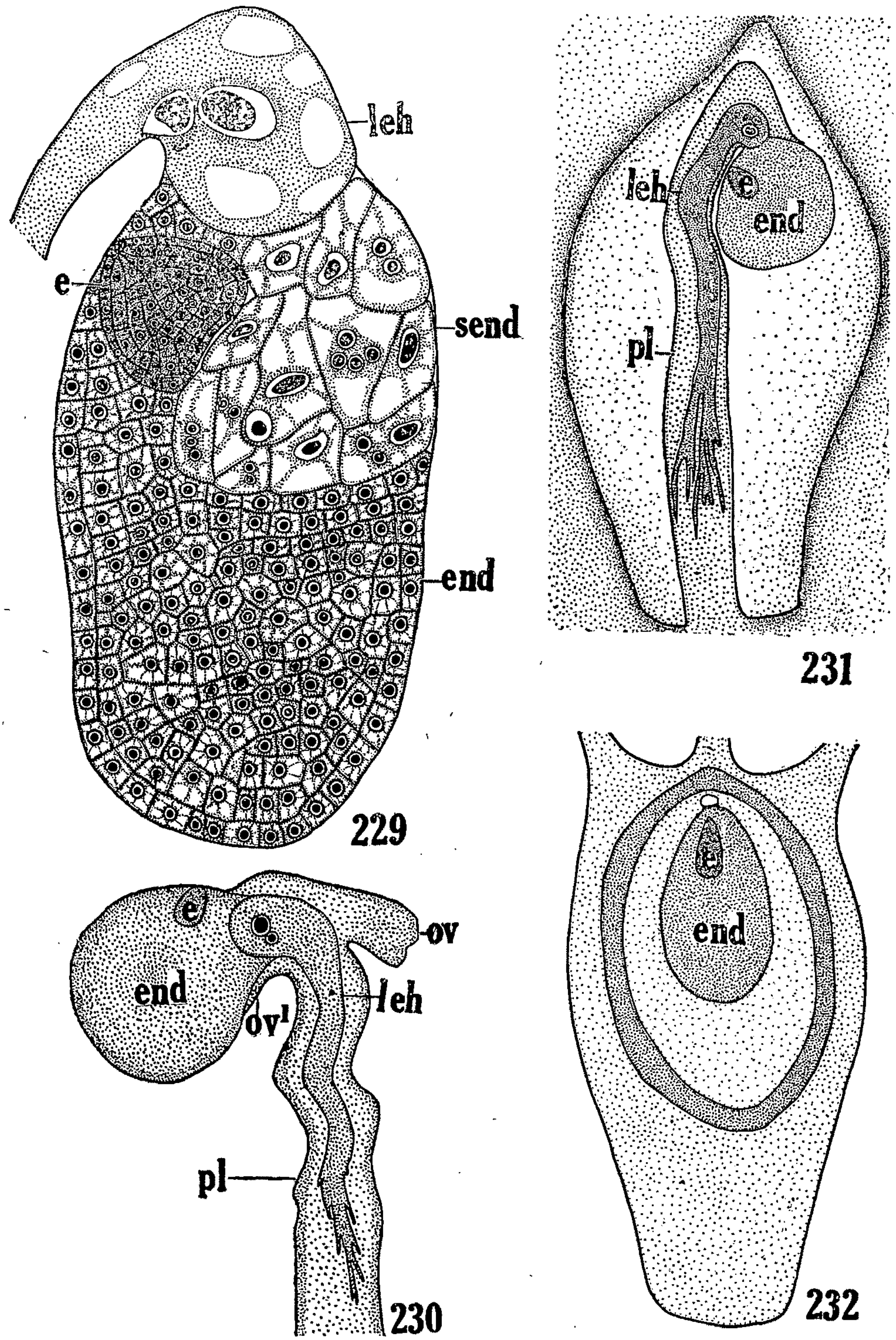
The chalazal embryo sac haustorium becomes very active in growth in post-fertilization stages, especially after the commencement of the endosperm formation. It considerably broadens and branches profusely in the lower part of the placenta devastating its tissue. Since in *Thesium* species the placental stalk is quite long, unlike *Santalum* and *Osyris*, the chalazal haustorium is not able to cross this stalk and enter the tissue below the base of the ovary cavity.

In *T. alpinum* the chalazal caecum is comparatively less vigorous than in the other two species. It usually does not branch much. and remains as a thin structure.

Endosperm.—As already stated above, the gigantic primary endosperm nucleus lies at the broad end of the embryo sac in vicinity of the laterally placed zygote. The first division of this nucleus is followed by the separation of the daughter nuclei by a transverse wall which divides the embryo sac in two compartments, a posterior or chalazal compartment and an anterior or micropylar compartment (Fig. 217). As characteristic of the family Santalaceae, the nucleus in the posterior compartment does not take part in the formation of endosperm but functions as the chalazal endosperm haustorial nucleus. As a rule this nucleus remains *in situ*, but may undergo one or two divisions, particularly in *T. humifusum* and *T. rostratum*. One or two of the daughter nuclei thus formed may migrate deep into the haustorium, while one nucleus always remains at the mouth of the haustorium. This nucleus gets hypertrophied and takes up irregular shapes (Figs. 220-224). Its nucleolus is also enormously enlarged. The other daughter nuclei in the haustorium are also later hypertrophied. Quite frequently the primary haustorial nucleus gets hypertrophied during the division stage. In such cases the division is not completed but a dumble shaped restitutional nucleus is formed (Figs. 220, 223).

The chalazal haustorium (*leh*) considerably broadens and shows vigorous activity under the influence of the endosprem haustorial nucleus. Its branches ramify in the lower part of the placenta, rendering the latter completely hollow.

Figs. 219, 220, l. s. embryo sacs showing further development of the endosperm. The zygote has been shifted more laterally in fig. 220. Fig. 221, l. s. part of the cellular endosperm surrounding the zygote which is in metaphase stage of divison. Figs. 222, 223, l. s. embryo sacs showing bi-celled proembryos and endosperm. Note the different positions in which the proembryos are lying in the embryo sacs. Fig. 224, l. s. embryo sac with four-celled proembryo and well developed endosperm. Note the inverted position of the embryo very near the chalazal endosperm haustorium. Figs. 225-228, further stages in the development of the embryo. Explanation in the text. Figs. 217-225, × 425; figs. 226-228, × 600,



TEXT FIGS. 229-232, Further stages in development of endosperm and embryo in *Thesium*.

The endosperm nucleus in the anterior or micropylar compartment (*fen*) surrounds itself by a differentiated cytoplasm. The divisions in the endosperm, which are confined to this compartment only, are cellular from the very beginning and start at the same level at which the zygote is placed laterally in the embryo sac. The primary micropylar endosperm cell divides in a longitudinal plane to form two elongated endosperm cells (Figs. 218 *end*). The second division is transverse in both the cells forming four isobilaterally arranged cells 219). Further divisions take place in both transverse and longitudinal planes without much regular sequence (Fig. 220) to produce several cells of endosperm filling the embryo sac cavity completely (Figs. 221-224 *end*).

As the endosperm cells are cut off mostly anterior to the zygote (or embryo), the latter is left in a lower position very near the chalazal endosperm haustorium and is completely surrounded by the endosperm cells (Figs. 220, 221, *zy*, 222, 224). Due to its continued growth the endosperm comes out of the ovule and lies free in the ovary cavity (Figs. 230, 231, *end*).

When a considerable amount of endosperm is formed, some of its cells lying opposite to the embryo and near the chalazal haustorium, enlarge and swell up to appear markedly different from the remaining cells of the endosperm (Fig. 229 *send*), and become haustorial in function. The nucleus in these cells divides twice or thrice so that each cell becomes four to six-nucleate. These nuclei soon get hypertrophied in a manner characteristic of the endosperm haustorial nuclei of the Santalaceae. It may be recalled here that in *Santalum* two types of haustoria develop in the endosperm ; one is the chalazal endosperm haustorium characteristic of the Santalaceae, and the other endosperm haustorium developed at the upper end of the embryo sac very near the zygote. This arises, when some of the free endosperm nuclei have reached near the zygote in the anterior compartment of the embryo sac, and has been called the upper (or micropylar) endosperm haustorium. It may be likely that in *Thesium* species these haustorial cells that develop in the anterior compartment are equivalent to the upper endosperm haustorium of *Santalum.* All the haustorial cells are finally crushed during the further growth of the massive endosperm.

Ultimately the endosperm becomes globular or pear shaped, and after displacing the central placenta it occupies the centre of the fruit (Fig. 232). It carries a single embryo embedded in it near the haustorial end, with only the mouth of the chalazal endosperm haustorium persisting there at the top. Due to the shifting of the endosperm to the central position, the embryo as

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(Fig. 230, *T. rostratum;* rest figs. *T. humifusum*) (*e*, embryo*; end*, endosperm*; send*, enlarged haustorial cells of the endosperm*; leh*, lower endosperm haustorium*; ov*, & *ov*^{1}, ovules*; pl.* placenta). Fig. 229, l. s. embryo sac showing many-celled embryo, the chalazal endosperm haustorium, massive endosperm with small cells, as well as some endosperm haustorial cells with many hypertrophied nuclei. Fig. 230, whole mount of mamelon with well developed endosperm and embryo. Fig. 231, l. s. ovary showing the lateral position of the endosperm and embryo in it. Fig. 232, l s. fruit. Note the endosperm and embryo have now occupied a median position. Fig. 229, x 200; figs. 230, 231, x 55; fig. 232, x 20.

well as the mouth of the chalazal endosperm haustorium, which are placed somewhat laterally in earlier stages (Figs. 230, 231), now occupy a median position (Fig. 232).

Embryo.—A study of the development of the embryo reveals an interesting phenomenon that the embryo occupies a reverse position from that of the zygote (cf. Figs. 217—224, 229-232). This change in the position of the embryo, which is mainly brought about by the unilateral growth of the endosperm and the displacement of zygote, has not been clearly elucidated by any worker so far. It may be recalled here that first division of the endosperm cell in the micropylar chamber takes place laterally to zygote and is in line with it. Due to an extensive growth of the endosperm on the anterior side the zygote is pushed laterally so that it comes to lie near the chalazal endosperm haustorium. By the continued growth of the endosperm tissue above the embryo, the latter is pushed more and more laterally until in older stages the orientation of the embryo appears to be inverted (cf. Figs. 229-232 *e*). Schulle (1933) has figured two such embryos (Figs. 8, i and k, p. 167) but has not explained it.

The activity of the zygote starts when the micropylar chamber of the embryo sac is filled up with endosperm cells. The first division of the zygote, which takes place in a transverse plane (Fig. 221 *zy*) forms a terminal cell (*ca*) and a basal cell (*cb*) (Figs. 222, 223). It is interesting to find that direction of the wall, segmenting the zygote to form a bicelled proembryo, differs depending upon the position of the zygote in the embryo sac. Thus in figure 222 this is at right angles whereas in figure 223 it is parallel to the embryo sac wall.

The second division in the proembryo takes place by a longitudinal wall in both the terminal as well as the basal cell. Thus at the second cell generation also the proembryo which is four celled, consists of two tiers only—*ca* and *cb*, with two cells in each tier (Fig. 224).

The third division results in the segmentation of the tier *ca* by a transverse wall to form *l* and *l′* (Fig. 225). The tier *cb* remains undivided for long. The cells in the tier *l* divide next by oblique walls, while l′ divides by transverse walls to form *ph* and *h* (Fig. 226), which then divide longitudinally to have four cells in each tier (Fig. 227). The cells in the tier l undergo a periclinal division to form eight cells. The cells in the tier *cb*, which have remained without division for long, also divide by transverse walls to give rise to *ci* and *m*. Both the cells in the tier *m* then divide by longitudinal walls to differentiate the peripheral cells (Fig. 228). When this stage of embryo is compared with a stage in which the differentiation of cotyledons has started (Fig. 229), it becomes clear that the tier l gives rise to the cotyledonary tissue and a part of the plumule, the tier *ph* gives rise to the remaining part of the plumule, *h* to the hypocotyledonary region, *m* and *ci* to the radicle. Evidently the derivatives of both the terminal as well as the basal cells take part in the formation of embryo and that no suspensor is formed.

Hofmeister (1858, 59) has described the presence of a small suspensor in *T. alpinum* and *T. intermedium*. According to Guignard (1885), on the other hand, no suspensor is formed in the embryo of T. *divaricatum*, and the whole of the zygote is utilised in the formation of the embryo. Modilewski (1928) on *T. intermedium* and Schulle (1933) on *T. montanum*, on the other hand have reported that of the two cells formed by the first division of the zygote, one functions directly as the suspensor which does not divide further and is soon degenerated. Their figures are, however, not very conclusive and it is good that Schulle has himself remarked that it must, however, remain open whether the development of the embryo takes place in the manner sketched above by him, or the egg cell becomes completely utilised in the formation of the embryo as assumed by Guignard.*

Rutishauser (1937) has sketched a many celled club-shaped embryo of *T. rostratum* (p. 43, Fig. 5d) and remarks that possibly the stalk like portion of the embryo represents the suspensor. A perusal of his figure however does not lend support to this. Rao (1942) has also reported that in *T. wightianum* the basal cell directly functions as the suspensor, while the terminal cell gives rise to a four-celled proembryo by a vertical wall followed by a horizontal wall. He Further writes that in *Thesium* suspensor elongates more than in the other genera, although it disappears early, but his figures 53 and 54 (p. 167) showing this condition are not very conclusive.

The early development of embryo in *Thesium* species shows a similarity with "Asterad" type of embryo development of Johansen (1950), and provisionally it may be assigned to its "Penaea" variation because of the following reasons:

(*i*) The first division of zygote is by a transverse wall.
(*ii*) The apical, as welll as the basal cell, divide by a longitudinal wall at the second cell generation.
(*iii*) The derivatives of both, apical as well as basal, cells are completely used up in the formation of the embryo proper and thus no suspensor is formed.

DISCUSSION AND CONCLUSIONS

The inferior ovary.—Van Tieghem (1869b), who was one of the earliest advocators of the appendicular nature of the inferior ovary, concluded from his observations on *Thesium* and *Osyris* that the ovary in Santalaceae also is appendicular. Similarly Dowding (1931) from his studies on *Comandra* and *Arceuthobium* concluded that the ovary in Santalaceae, as well as Loranthaceae, is appendicular. In a recent paper Rao (1942) writes for *Santalum album*, "During the development of the flower the gynaecium becomes semi-inferior or inferior as a result of partial fusion between the carpellary walls and the perianth."

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*While this paper was in press, I came across a note on *Comandra* by Ghosh (1955. *Curr. Sci.* **24**: 280-81). She reports that the embryo is characterised by the absence of a suspensor.

Evidently he believes that the ovary is appendicular. Saunders (1939) who has studied the course of vascular supply in *Colpoon, Osyris* and *Thesium*, has, however, not commented on the nature of the inferior ovary.

To the other group, who consider the ovary of Santalaceae to be receptacular, belong Schaeppi and Steindl (1937), Schaeppi (1942) and Smith and Smith (1942 a, b). Schaeppi and Steindl (1937) working on *Osyris alba*, and Schaeppi (1942) on *Thesium alpinum* and *T. rostratum*, concluded on the basis of ontogenic and morphological studies that in Santalaceae the ovary is embedded in the tissue of the receptacle. Smith and Smith (1942 a, b) who have studied the floral anatomy of 24 genera, comprising 40 species of this family, have tried to furnish definite anatomical proofs in favour of the receptacular nature of the inferior ovary. The present author does not agree with Smiths' interpretations of the course of the vascular supply and the mode of origin of the inferior ovary. In order to have a clear conception it would be better to consider Smiths' main thesis first.

Smiths find that in *Darbya*, and some other primitive Santalaceous genera, two rings of stelar bundles are present in the ovary wall. The outer ring, consisting of normally oriented bundles, is the main receptacular ring, while the inner ring, consisting of inversely oriented bundles, represents a recurrent ring. The latter is connected with the main ring somewhere near the top of the ovary. The carpellary supply in these plants is not given off directly from the main receptacular ring, but from the recurrent ring of bundles near the base of the ovary. It has been inferred, therefore, that the outer part of the ovary wall, which is traversed by the stelar bundles, is receptacular at least upto the level where the recurrent traces arise. Some of the recurrent bundles continue their downward course, even after supplying the carpels, and terminate in the pith region lower down at the base of the flower. These portions of the recurrent bundles, that are left unused, have been called by Smiths as 'residual traces' of the floral axis.

In *Darbya* the recurrent traces are most prominent and are connected with main vascular supply near the top of the ovary. This condition according to Smiths, is found only in primitive genera of Santalaceae. In other genera, which are more advanced, the condition is, however, different. In some plants recurrent traces are connected with the main vascular supply at a much lower level, while in others they cannot be made out as clear and separate traces in the ovary wall. To explain this Smiths have suggested that either the recurrent traces have fused with the main vascular supply, which has become amphicribral (e. g. *Colpoon*), or they have become increasingly reduced and weaker in more advanced forms to be ultimately lost (e.g. *Choretrum, Henslowia, Omphacomeria, Thesium, Thesidium*). According to them in such plants, with reduced or entirely lacking recurrent traces, the receptacular nature of the inferior ovary is indicated by the presence of residual tissue, which has persisted in the pith region at the base of the flower, and due to the complete loss of recurrent traces, these have become connected upwards and outwards with the bundles of the main vascular supply near the base of the ovary.

Thus according to Smiths there are three chief characteristics of the inferior ovary of Santalaceae : (a) the presence of a ring of recurrent inverted bundles; (*b*) the origin of the carpellary supply from the recurrent ring; and (*c*) the downwardly pointed residual tissue. From these features they conclude that the inferior ovary in Santalaceae has originated as a result of 'invagination' or 'sinking' of the floral axis in the form of a cup, and the subsequent fusion of the resultant cup-shaped receptacle to the ovary. The bundles in the main vascular supply ascend up to the brim of the receptacular cup, in its normal course, and there the supply to stamens and perianth is separated. But since the carpels originate at the bottom of the receptacular cup, some of the stelar bundles descend down to the base of the flower, to send the dorsal and the ventral carpellary supplies. The remaining part of the recurrent traces represents the residual tissue which points downwards.

Smiths infer, from a comparison of the situation in *Darbya* with that in *Rosa* and some other genera of Rosaceae described by Bonne (1928) and Jackson (1934), that the invagination of the receptacle in Santalaceae has taken place somewhat like in Rosaceae. As a complete progressive series illustrating this phenomenon is not available in Santalaceae, they think that "the progenitors of Santalaceae may have had a structure similar to *Rosa*" (Smith and Smith, 1942 a, p. 470) and "the condition in Rosaceae could well represent the beginning of such a series".

The most interesting part of their theory is that in an appendicular type of inferior ovary the residual traces of the floral axis are directed upward, while in a receptacular inferior ovary these traces are directed downward. This is because of the fact that due to extreme 'invagination' or 'sinking' the floral axis becomes inverted and thus points down. If the axis points upward the residual tissue would also point up and vice versa. Puri (1951,52 a) does not agree with Smiths' interpretation of the inverted floral axis in Santalaceae. He has put a very pertinent question, "If the axis in *Darbya* were to become inverted, how could the orientation of the gynaeceum remain unaffected?" He goes on to say (Puri, 1952 a, p. 123) that "......terms like '*sinking*' '*impushing*' '*invagination*' etc., when used in connection with the floral axis, are just descriptive terms, which are used to describe the peculiar type of differential growth, characteristic of certain floral axes. The usage of such terms, therefore, should not involve any idea of an inversion of the floral axis, which these authors want us to believe."

The present author, who agrees with Puri, (1952) further feels that if Smiths' view of residual traces is to be considered as correct, it will not only mean that the axis of Santalaceous flower points downwards but also that it has actually undergone a downward growth as indicated by the continued downward extension of the residual traces, sometimes even into the pedicel of the flower (Smith and Smith, 1942 a, p. 469; 1942 b, p. 16).

Usually in all flowers having superior or inferior ovaries the distal bundles of the receptacular stele, left after the supply to sepals, petals and stamens commonly become the traces for the carpels and are completely used in supplying this last floral organ. It is only infrequently that some stelar tissue is left after the supply to the carpels has been sent. This residual tissue of the floral axis is usually represented by procambial strands only (see Eames and Mac Daniels, 1947). Even in those cases where the inferior ovary has been considered to be receptacular due to the presence of recurrent traces,* it has been found that all the recurrent bundles are used up completely in supplying the carpel and no downwardly pointing residual traces of the floral axis are left at the base of the ovary. The residual traces of the floral axis occuring as a very regular feature, and pointing down, is, however, only peculiar to the Santalaceae described by Smith and Smith (1942 a, b).

The floral anatomy of the members of the Olacaceae, the supposed nearest ancestors of Santalaceae, has also been worked out by Smith and Smith (1942 b). The presence of 'residual traces' in this family has been noted only in *Strombosia philippinensis*. In other plants of this family having superior or appendicular inferior ovaries no residual traces are left (see Smith and Smith, 1942 b).

In majority of the Santalaceous genera, where no recurrent traces can be made out, but the 'residual traces' are seen in the pith region at the base of the flower, they are connected with the bundles of the main vascular supply near the base of the ovary (Smith and Smith, 1942b). To explain such conditions Smiths have suggested that in these forms the recurrent bundles have been lost through reduction, while their terminal or distal portions have persisted as residual traces, which have established new connections with the bundles of the main ring. This is difficult to understand in view of the fact that usually the reduction of any vascular supply begins from the organ (distal end) and not from the origin of the supply (the proximal end).

All the above objections to Smiths' interpretation of *the residual traces of the inverted floral axis* can be easily satisfied only if these traces are regarded as a residue of the carpellary supply. In order to clarify this view further it is necessary to understand the probable mode of origin of the inferior ovary in Santalaceae.

The apical growth of the axis in flowers having inferior ovaries, is stopped at an early stage. Further development of the flower takes place by a lateral growth of the receptacle or an intercalary growth of the bases of the floral organs, as shown by Puri (1951, 52 a). He suggests that the appendicular or receptacular nature of the inferior ovary depends upon the localisation of the zones of active differential growth (see Puri, 1952 a, p. 127, Figs. 1-3) It can be seen from his figures that there can be at least two types of receptacular inferior ovaries. If the growth is most active in the middle layers of the receptacle, outside the zone of origin of the vascular supply to carpels, the ovary will be mainly receptacular. But the vascular ground plan of this type of inferior ovary will, however, be almost similar to that of the appendicular ovary, because in this case the vascular supply to the carpels will not be involved in the zonal growth, and will not appear to be recurrent. If on the other hand the differential growth is most active in the inner zone involving the vascular supply to the carpels, the upward growth of the receptacle will cause the vascular strands, giving off the carpellary traces, to appear recurrent for some distance.

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*See Bonne (1928), Jackson (1934), Mac Daniels (1940) on Rosaceae, and Smith (1928) on Calycanthaceae.

Now the differential growth of the receptacle, which is always lateral, will not involve the terminal portion of the receptacular stele, but only its lateral flanks. Thus the distal portions of the receptacular bundles which sometimes form the residual traces of the floral axis will continue to point upward in the flower; these cannot possibly point downward as shown by Smith and Smith (1942 a, b).

In the other case, which is more frequent, where the distal portions of the receptacular stele completely become the traces for the carpels (and no residual traces of the floral axis are left), it cannot be said easily at what level they cease to remain stelar and become appendicular or carpellary (see also Puri, 1951). Similarly it is not practically possible to say upto what level the recurrent traces are stelar and where they become appendicular. It can, however, be agreed upon that at least the terminal portions of the recurrent traces, which take a turn to enter the carpel, are appendicular and the residual tissue, left unused, should represent the residue of the carpellary supply, rather than the residual traces of the floral axis as maintained by Smith and Smith (1942 a, b).

This fact will be further strengthened after a perusal of the condition of the vascular supply of flower of *Santalum*, *Osyris* and *Thesium* species described by the present author, where the dorsal and ventral carpellary supplies have independent origin. Smith and Smith (1942 a, b) have, on the other hand, shown in *Darbya* that the dorsal and ventral carpellary supplies have a common origin from the recurrent traces, which is, however, found only exceptionally. In all the plants studied by the present author, those bundles which are destined to form the ventral carpellary supply are given off first from the receptacular stele, and therefore, only these bundles appear to be recurrent for some distance due to the zonal growth of the receptacle in this region. The dorsal carpellary supply, which originates from the main ring at a slightly higher level (see Figs. 12, 105, 155 and 165), continues straight upward and does not appear to be recurrent.

It has often been found that all the vascular traces given off for an organ are not completely used in supplying it, and some of them may be left at the base of the organ (see also Puri, 1951). It may be pointed out here that flowers of the family Santalaceae, have suffered a marked reduction in their reproductive organs, especially the placenta and the ovules. The reduced nature of these structures is very clearly evidenced by the comparative morphology, as well as from the vascular supply entering the placenta. In consists of a single compound vascular bundle which is the fusion product of all the ventral carpellary traces.* Naturally, therefore, all the traces meant for supplying the ovules do not enter the placenta but some of them are left lower down at the base of the ovary. Thus the residual tissue present in the pith region at the basal part of the flower in *Osyris*, *Santalum* and *Thesium*, represents the residue of the ventral carpellary supply.

Smiths have also observed that in several genera of Santalaceae, including *Osyris*, *Santalum*, and *Thesium*, the recurrent traces, from which branches enter the placenta as the ventral carpellary supply, are connected with the main vascular ring at the base of the ovary. The dorsal carpellary traces arise at a higher level from the main vascular supply. Smiths consider *Darbya* to be representing the primitive condition of the vascular supply in Santalaceae and try to interpret the condition in all other genera derived by a reduction through the disappearance of the proximal parts of the recurrent stelar traces, leaving only their distals parts as residual traces, which is not acceptable for reasons already given. It may further be added that the morphological features of *Darbya* as well as the condition of its placenta and the ovule do not warrant it to be a primitive genus of Santalaceae, rather it appears to be much reduced. Therefore, Smiths' interpretations of the floral anatomy of *Osyris*, *Santalum* and *Thesium* and other genera of Santalaceae, on the basis of conditions observed in *Darbya*, cannot be held. Thus as pointed out by the present author in *Osyris*, *Santalum* and *Thesium*, majority of other Santalaceous genera also where the residual traces are the continuation of the recurrent ventral carpellary traces, these may be safely considered to be the residue of the ventral carpellary supply.

The present observations on the floral anatomy of *Osyris* and *Santalum* indicate the possibilities of the presence of more than one region of active differential growth which may lead to the formation of the ovary wall in these plants. The first zone of active growth is in the inner regions of the receptacle. In *Santalum* this growth zone appears to be more active which causes the standards forming the ventral carpellary supply to appear recurrent for a considerable distance. In *Osyris* the growth in this zone is comparatively less as indicated by the short distance for which the ventral carpellary traces become recurrent. The second zone of growth lying in the extreme peripheral parts appears to be more active in *Osyris* and contributes to the formation of the floral tube which fuses with the upper part of the ovary. This fact is very clearly elucidated from a study of comparative morphology of the male flowers of *Osyris* with the seemingly hermaphrodite (really male-sterile) ones. In the former the perianth is gamophyllous and the stamens as well as the disc are epiphyllous, just as in other genera of Santalaceae. In the seemingly hermaphrodite flowers of *Osyris*, on the other hand, the perianth is apparantly polyphyllous and the stamens as well as the disc appear at the top of the ovary and thus do not appear to be epiphyllous. The epiphyllous glandular hairs, so conspicuous in the male flowers, are also totally wanting in the seemingly hermaphrodite ones. All these facts indicate that in the latter type of flowers the gamophyllous region of the perianth has fused with the ovary for a considerable distance. Thus the ovary wall in *Osyris* is receptacular below and appendicular above.

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*Eames (1951) maintains that with a reduction in the number of ovules on a free central placenta, all the vascular bundles entering it may become fused into one mas

In *Thesium* species there is very little differential growth in the inner region of the receptacle, as here the strands forming the ventral carpellary supply appear to be recurrent for a negligible distance. Thus the wall of the inferior ovary is formed by the growth in outer regions of the receptacle only. As has been shown by Puri (1951, 1952 a) in such cases the vascular supply does not give any sure indication of the true nature of the ovary wall and detailed histogenetic and cytological studies of the receptacle may yield more reliable evidence.

A peculiar feature observed in Santalaceous flowers is that a number of traces, other than the dorsal carpellary traces, depart from the main ring to enter the ovary wall, where they either end blindly or fuse with the dorsal carpellary traces (see Figs. 12, 105, 155). These traces have been designated as 'X' traces by Smith and Smith (1942 a, b), who consider them to be "merely anastomosing cross branches of no morphological significance." Further, however, they add that because of their consistent appearance in several genera of this family, they may have some significance not yet understood. The present author can think of two possibilities for these 'X' traces ; (*a*) they belong to carpels now extinct, or (*b*) they may be stelar bundles that have made their way into the ovary wall. A perusal of the systematic literature on Santalaceae reveals that the present forms mostly have three carpels, though some forms like *Henslowia* have yet retained four or five carpels, as were present in their ancestors (see Engler and Prantl, 1935; Smith and Smith, 1942 b). If the above contention of the reduction of the carpels is correct the extra traces '(X' traces) entering the ovary wall, could be the remnants of the vascular supply to the lost carpels. Such a view has also been held by Bechtel (1921) working on Urticales, and Swamy (1949 a) on Degeneriaceae. Henslow (1890) found that in the pistil of *Lathyrus*, instead of there being three well developed cords, a complete ring is present which has to be utilised by the single carpel. He interpreted the extra bundles as stelar which have made their way into the last floral organ. Nast (1944), working on Winteraceae, has also arrived at the same conclusion. Puri (1951) also appears to agree with this view. In Santalaceous flowers there are a large number of strands comprising the main ring of vascular supply which is left after dorsal and ventral carpellary traces are given off. All of these are not utilised in supplying the stamens and the perianth, and, therefore, the remaining bundles end blindly in the upper part of the flower. It is plausible to think that some of the traces from this ring, which are not to supply any other part, enter into the ovary wall, especially near the top of the ovary. It is important to note that these extra bundles either reinforce the dorsal carpellary bundles or end blindly in the ovary wall but are never seen to have entered the style as independent bundles.

Vascular supply to stamens and perianth.—The staminal supply arises from the main vascular ring at the level of the top of the ovary. Two lateral inverted bundles, present one on each side of every perianth trace, take an inward swing to lie opposite to the perianth traces. There they fuse to form a compound bundle, which consists of phloem only. The xylem, which is left behind, fans out and ends blindly. At the level where the staminal filament becomes independent, the compound phloem bundle enters into it.

In *Darbya* Smith and Smith (1942 a, b) have described a very dubious course of vascular supply to the stamens. They report that some of the bundles of the recurrent ring, that are present opposite to the parianth traces, do not connect with the main vascular supply, but fuse with each other to form compound amphicribral bundles lying against the perianth traces. These amphicribral bundles later enter the filaments. It would mean that the recurrent strands, which are really facing down to supply the ovary wall and the ovules after reaching the base of the flower, also enter into the filament from their basal ends, as it were, to supply the anthers higher up in the flower. This is highly improbable as these recurrent traces lying against the perianth traces will exist unconnected with the main vascular supply throughout their course, while those lying between the perianth radii will be connected. From what has been observed by the present author in *Osyris*, *Santalum* and *Thesium*, it is certain that Smiths have confused the origin of staminal traces, on account of their inverted nature, with the inverted bundles of the recurrent ring, running against the perianth radii.

The course of vascular supply to stamens in Santalaceae reminds of a somewhat similiar feature found in some of the Rubiaceae. Saunders (1939) reports in *Asperula* that two lateral veins of the petal midribs converge and touch each other at the level where the staminal filaments spring from the corolla tube, but the laterals diverge again to enter the petal lobes, without leaving any vascular supply for the stamen. It is probable that in *Asperula* when two lateral veins touch each other, some procambial or phloem tissue might be left over as a staminal supply.

The xylem strands left in Santalaceous flowers in the corresponding position, after the supply to stamen has departed, may be the vascular supply to the lost petals. The vascular supply to the present whorl of perianth in the Santalaceous flowers also confirms this view. In all the three genera studied here, as well as majority of other genera of this family (see Smith and Smith, 1942 b), each bundle in the perianth position divides into three. Thus each perianth lobe receives three bundles, one median and two laterals, which may divide further in majority of cases, so that several bundles are produced in each perianth lobe, somewhat like that of the condition found in sepals. This indicates the sepaloid nature of the perianth lobes present in Santalaceae. All these conditions lead to the conclusion that the Santalaceous genera are apetalous; the petals having been lost through reduction, and the present whorl of perianth is actually the calyx. Smith and Smith (1942 a, b) also consider the Santalaceous genera to be apetalous.

It is interesting to note that the vascular supply to stamens and perianth in *Dendrophthoe falcata* (Singh, 1952) is also somewhat similar to that described above for santalaceae In this plant, as well as *Macrosolen cochinchinensis* (Maheshwari and Singh, 1952), each perianth lobe receives three bundles, one median and two laterals, indicating towards the sepaloid nature of the perianth.

The mamelon and the place of origin of the female gametophyte.—In Santalaceae, as well as Myzodendraceae (Hofmeister, 1859; Johnson, 1889; Skottsberg, 1913, 14) and some members of Loranthaceae (Treub, 1881; Schaeppi and Steindl, 1942; Maheshwari and Singh, 1952), the ovary cavity is occupied by a central structure called mamelon which carries varying number of lobes, usually three. These lobes form the seat of origin of the female gametophyte. There has been great diversity of opinion about the interpretation of this mamelon. Griffith (1844) suggested this to be a free-central placenta bearing three pendulous ovules. Hofmeister (1859) thought that the centrally elongated structure in the ovary cavity of *Hyphear europaeum**represents a single basal ovule on which several groups of archesporial cells are differentiated. Treub (1881, 1883, on *Macrosolen cochinchinensis* and *Dendrophthoe pentandra*) considered it to be a continuation of the floral axis in the ovary cavity and called it as '*Mamelon*', a term which is now widely in use. The lobes of the mamelon were considered by him as the nucelli of the rudimentary ovules. Guignard (1885, on *Thesium*, *Santalum* and *Osyris*) agreed with the interpretations of Griffith and Treub.

Dowding (1931, on *Comandra* and *Arceuthobium*) and Saunders (1939, on *Colpoon*, *Osyris* and *Thesium*), on the basis of carpel polymorphism considered the mamelon to be representing the fertile and the ovary wall the sterlie whorl of carpels.

Most of the recent workers on Santalaceae (Modilewski, 1928; Schulle, 1933; Iyengar, 1937; Schaeppi and Steindl, 1937; Rao, 1942; Schaeppi, 1942; Smith and Smith, 1942 a, b) agreeing with Griffith (1844) and Treub (1881, 1883) have interpreted the mamelon as a free-central placenta bearing three pendulous ovules near its tip. Fagerlind (1948) has called the mamelon as the "Zentralplazenta—Samenanlagen—Komplex oder Zentralsaüle—Samenanlagen—Komplex." In the Loranthaceous genera also the mamelon is considered as central placenta with much reduced ovules in the form of lobes (Schaeppi and Steindl, 1942; Maheshwari and Singh, 1952). The present author who also agrees with this interpretation of mamelon (Paliwal, 1953) has used it to denote the free-central placenta along with the ovules attached near its tip in *Osyris*, *Santalum* and *Thesium*.

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* The names of the members of Loranthoideae given here are based on Danser' (1929, 31) classification.

It, however, remains to be decided whether the free-central placenta in Santalaceae is foliar or axial in nature. Opinions of workers on this point have been divided. It has often been compared with the free-central placenta of Primulaceae (Engler and Prantl, 1935; Schaeppi, 1937; 1942; Schaeppi and Steindl, 1937; Wilson and Just, 1939). Van Tieghem (1869a), who first reported the placenta of Primulaceae to be axial, later on considered it to be foliar, as indicated by the inverted orientation of the vascular bundles in it. On the same basis he concluded the placenta of Santalaceae also to be entirely carpellary (Van Tieghem, 1869 b). Henslow (1890) found rounded and amphicribral placental bundles in Primulaceae and thought that they were appendicular. Smith and Smith (1942a, b) also have concluded that the placenta in Santalaceae is entirely carpellary, because the floral axis which has become inverted in Santalaceous genera (due to an 'invagination' or 'sinking' of the floral axis, causing the ovary to become inferior) could possibly take no part in its formation. However, the entirely carpellary nature of the placenta on the above ground only cannot be held, since Smiths' conception of inverted floral axis, as already shown, is not quite convincing.

Johnson (1889); Iyengar (1937); Rao (1942) are among the supporters of the axial nature of the placenta. Rao (1942) writes, "In *S. album* the floral axis forms a concial projection in the completed ovary cavity and upon it three ovules are differentiated in a basal or slightly lateral position." None of these workers, however, has furnished any proof in favour of this view. Puri (1952 b, p. 692) has, therefore, rightly remarked, "The casual reports that the placental column in Santalaceae is 'axial' (Johnson, 1889; Rao, 1942) cannot be taken seriously."

Heinricher (1932, 33), Dickson (1936), and Schaeppi (1937) on the basis of teratological, anatomical and ontogenic studies respectively have shown that the free-central placenta in Primulaceae is composed of carpellary margins with some axial tissue extending into its central part.* This view has now been largely accepted (see Douglas, 1936 ; Wilson and Just, 1939; Eames, 1951; Puri, 1951, 52 b). Schaeppi (1937) and Schaeppi and Steindl (1942) have similarly concluded mainly on the basis of ontogenic studies that in Santalaceae also the free-central placenta is mainly carpellary in its peripheral part and axial in centre.

Puri (1951) mentions that the histogenic studies on the origin of floral organs from different layers of the floral apices can clearly elucidate their morphological nature. Lawalree (1948) has shown that all the floral organs are derived from the second layer of tunica like the foliage leaves. Boke (1949) has also shown that in *Vinca rosea* the stamens and the carpels are initiated from the second layer of tunica. Satina and Blakeslee (1941, 43) have tried to solve the problem of the nature of the swollen placenta of Solanaceae with the help of periclinal chimeras and the cytological study of cells in their different layers. They have shown that the shoot and the floral apices are quite similar, at least in that both have three independent germ layers L_1, L_2, L_3. The other cells of the central core (pith) lying within L_3 are descendents of this last germ layer (L_3). By a study of the initiation of the floral parts from these layers, Satina and Blakeslee (1941, 43) have shown that the sepals and petals resemble leaf as they originate by the activity of L_2. The initiation of the carpel and the early development of its walls, septa and placenta, depends primarily on the activity of the innermost germ layer L_3. In later stages cells from L_2 only contribute chiefly to the growth of the carpel wall and the septa. The cells of L_3 continue to predominate in the formation of the placenta, the lower portion of the carpel and the septa, which are, therefore, axial.

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*In some genera of Caryophyllaceae, Portulacaceae and Primulaceae the free-central placenta shows the presence of a ring of normally oriented bundles (of axis) in addition to the inverted bundles (of ventral carpellary supply). This is a definite anatomical proof to show that the placenta in these families represents carpel margins, with axial tissue in the centre (Eames, 1951).

The present author has found that in *Thesium* species the perianth, stamens, as well as, the carpel wall are initiated as a result of the second layer of the torus, and therefore, they are all foliar. The projection of the torus left in the centre is differentiated as the mamelon. Thus the placenta differs in its origin from other floral organs, because apart from the outer two layers, deeper layers forming the central core of the torus also are utilised in its composition.

The further growth of the placenta, however, is brought about mainly by the activity of the outer two layers only. These layers also form the ovular primordia close to tip of the young placenta. In *Osyris* and *Santalum* the development of the placental stalk, elevating the ovules, is brought about by an intercalary cambial growth at the base of the placenta, which is characteristic of axial tissue. In *Thesium* species this elevation, which is more pronounced, is carried further by an extreme enlargement of the cells forming the placental stalk. Thus it may be concluded that the placenta in Santalaceae is carpellary in its peripheral part where the ovules are differentiated, but it also possesses some axial tissue in the centre, at least in the basal part.

In the plants having free-central or basal placentae, the foliar nature of the ovules also has been questioned. Coulter and Chamberlain (1912) believed that the cauline ovules should be more common than foliar in such plants. In Myricaceae (Kershaw, 1909) and Juglandaceae (Shuhart, 1932; Langdon 1939) having basal placentation; and Primulaceae (Lam, 1948) and Santalaceae (Johnson, 1889; Rao, 1942) having free-central placentation, the ovules have been interpreted to be cauline. Satina (1945) from a study of periclinal chimeras in *Datura* concluded that in this plant, and also probably in the whole family Solanaceae, the ovules are cauline. Lam (1948) has concluded in his '*New Morphology*' that the foliar or cauline nature of the ovules is determined by their position on the placenta. Thus ovules borne on axile or parietal placentae are foliar, while those on free-central or basal placentae are cauline. Eames (1951) and Puri (1952b) have, however, shown very clearly that the free-central placenta has been derived from axile placentation, and the basal placenta from either parietal or free-central placentation through reduction. Lam's (1948) conclusion about the foliar or cauline nature of the ovule on the basis of the type of the placentae is, therefore, very superficial and the ovules on all types of placentae can be very well considered as foliar (see Eames, 1951; Puri, 1952b).

Since the free-central placenta in Santalaceae is carpellary at least in its peripheral part, the ovules which arise as a result of the activity of its two peripheral layers only, are definitely foliar in nature.

The ovules of the Santalaceous genera, which are represented as three lobes of the mamelon, have usually been described to be naked by most systematists and other old morphologists (see Goebel, 1933; Coulter and Chamberlain 1912). This applies more specifically to *Santalum* (Griffith, 1844; Henfrey, 1856; Schacht, 1866; Strasburger, 1878, 85; Iyengar, 1937; Rao 1942) and *Osyris* (Griffith, 1844; Jönsson, 1880; Rao, 1942). Opinions have, however, differed in respect to *Thesium* species. Thus majority of the early workers on this genus (Schacht, 1850; Hofmeister, 1858, 59; Jönsson, 1880; Guignard, 1885) believed the ovules to be naked. Warming (1878), who has been the pioneer worker on the morphology of ovule, however, suggested that the ring of cells at the top of the nucellus in *Thesium* may actually be the remnants of an integument, and the ovule may, therefore, be not completely naked. Schnarf (1929) also held that the condition in Santalaceae may be somewhat similar to that of Apocynaceae and Asclepiadaceae where the integument is so completely fused with the nucellus that ovule appears naked. Schulle (1933) and Rutishauser (1937) working on *T. montanum* and *T. rostratum* respectively, have demonstrated the presence of a reduced integument, bulging out only slightly at the top to form a rudimentary micropyle. Rao (1942) has also reported the presence of a rudimentary integument in *Thesium wightianum* and *Scleropyrum wallichianum*.

The present author has observed that in *Osyris*, *Santalum* and *Thesium* the nucellus is very narrow and is represented by a few layers of elongated and richly cytoplasmic cells only. The remaining bulk of tissue present laterally to this narrow nucellus represents the integumentary tissue, which develops in union with the nucellus. The major growth of the ovule is brought about by divisions in the lateral tissue, a characteristic feature of the integument, while the central nucellar tissue keeps pace with this growth of the ovule mainly through an elongation of the cells, a characteristic feature of the tenuinucellate ovule. In *Thesium* species the integumentary tissue bulges slightly beyond the upper epidermis of the nucellus, forming a small rudimentary micropyle. This makes the detection of integument in this genus comparatively easy. In *Osyris* and *Santalum*, on the other hand, the integumentary tissue does not at all grow beyond the level of the nucellus and hence no micropyle is formed. This makes the detection of integumentary tissue apparantly difficult.

From the general trend of reduction in the ovule, it is clear that there has been a tendency towards the reduction of the nucellus, which is, sometimes represented by a few archesporial cells only, capped by a single layer of epidermis. Such condition is found in Asclepiadaceae and Rubiceae in particular, and the Sympetalous families in general (see Schnarf, 1929, 31; Fagerlind, 1937;

Maheshwari, 1950). The reduction of the integument on the other hand has been comparatively slow. Thus even in some of the advanced families, where the nucellus has been reduced to a single layer, one finds the presence of a thick integument. It is quite plausible, therefore, to regard the Santalaecae as having a reduced nucellus with the female gametophyte developing in direct contact with the fused integumentary tissue.

It should, therefore, be clear that in Santalaceae the lobes of mamelon represent unitegmic ovules which are much reduced. Further the seeds of Santalaceae are naked because of the fact that in majority of these plants the egg comes to lie outside the ovule and the embryo and endosperm develop in the ovary cavity, directly covered by the fruit wall.

Formerly Rubiaceae and Olacaceae were supposed to have naked ovules but now these have been clearly shown to possess an integument (Fagerlind, 1937, 48). This integument is sometimes found to be completely fused with the reduced nucellus in some of the members of Rubiaceae and is difficult to detect. Fagerlind (1937) has shown by a very close series of diagrams the method of reduction of the nucellus and the fusion of the integumentary tissue in Rubiaceae which has its culmination in *Haustonia*, where the nucellus is represented only by a few archesporial cells directly embedded in the fused integumentary tissue.

Fagerlind (1945) has also tried to show the mode of reduction of the ovules in the Santalales. Starting from a flower of some hypothetical member of the Santalaceae he has shown the way in which the peculiar condition of Balanophoraceae might have arisen. The basic scheme of reduction appears to be correct, but his figures illustrating the conditions of Santalaceous genera, especially *Santalum* and *Osyris* are, however, not at all true representatives of the actual condition. He has also not considered in his scheme of reduction those forms of the Loranthaceae which are characterised by the presence of a mamelon, somewhat similar to that in the Santalaceae.

It may now be safely concluded that the simple structure of the ovule in Santalaceae is not primitive but has been derived through a progressive reduction (see also Fagerlind, 1948). This should also apply to *Exocarpus*, and the simple structure of ovule in this plant should not be regarded as a primitive feature to warrant it to be a member of Protangiospermae as maintained by Lam (1948). On the other hand it should be considered to be representing a much reduced condition. Eames (1951) has also concluded that *Exocarpus* is a dicotyeldon and occupies a relatively advanced position in this group.. Swamy (1949 b) has shown it to be a genus of Santalaceae on the basis of anatomical evidence.

It is interesting to note that in *Santalum* the beak of the mamelon extends into the stylar canal so that the ovary appears to be only semi-inferior (see Figs. 8, 9, 12 and also Rao, 1942; Smith and Smith, 1942 b; Fagerlind, 1948). In this respect it is markedly different from other genera of Tribe Osyrideae, which have a completely inferior ovary. In *Eucarya* also where the ovary is considered only semi-inferior (Smith and Smith, 1942,b) the beak of the mamelon extends into the short style, much like the condition in *Santalum*. A doubt is naturally created in our minds about the nature of the free portion of the gynaeceum accommodating the beak of the mamelon in these genera of Santalaceae.

The present author has shown that in *Osyris* there is a clear indication of the obliteration of the lower part of the ovary through its solidification from base upwards, so that only very little cavity is left in the upper part of the ovary. The small cavity is compactly filled by the mamelon. Troll (1928) has shown that if the original fertile part of the gynaeceum is solidified, the fertility zone tends to be shifted to the paracarpous* region in the style (see also Laubengayer, 1937; Wilson and Just, 1939). The present author feels that in *Santalum* also, which is more advanced in reduction than *Osyris*, the lower part of the ovary having become solidified, the ovules are born in the extreme upper part of the ovary. The ovary cavity here is continuous with the wide stylar canal. As already said (p. 197) the chalazal parts of the ovules grow up in union with the placenta to form the beak of the mamelon which extends in the style. This is the region where the elongated, free micropylar arm of the embryo sac is accommodated. It would mean that in *Santalum*, just like other members of the tribes Osyrideae and Thesieae, the original part of the ovary is completely inferior, while the superior and free part of the ovary corresponds to the style, which has now taken up the function of the ovary. One can easily conceive of such a condition having occurred, if he imagines of the development of a beak of the mamelon in *Osyris* and its extension into the stylar canal.

The condition found in a number of Loranthaceous genera is also interesting in this respect. Here the embryo sacs enter into the stylar region for a considerable height. Singh (1952) on *Dendrophthoe falcata* has opined that here the part of the style into which the embryo sacs extend may be considered to be the ovary simulating a style, while the part above it may represent the true style.

Megasporogenesis and development of female gametophyte.—As a rule a number of archesporial cells differentiate in each ovule and directly function as megaspore mother cells. Iyengar (1937) and Rao (1942) have on the other hand reported the formation of wall layers capping the developing megaspore mother cells. As already pointed out this conclusion seems to be based on the study of oblique sections of the ovule where some of the integumentary cells appear to be capping the megaspore mother cell and can be mistaken to be wall layers. Guignard (1885); Modilewski (1928), Schulle (1933), Rutishauser (1937), Schaeppi and Steindl (1937), have all reported that the female archesporial cells are transformed into megaspore mother cells without cutting any wall cells.

All the megaspore mother cells formed in an ovule are not functional. A number of them are arrested in growth and degenerate. Thus in *Santalum* usually one (rarely 2), in *Osyris* one to three, while in *Thesium* as many as six mother cells may develop to megaspore tetrad stage in each ovule.

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*Schaeppi and Steindl (1937) in *Osyris alba*, Schaeppi (1942) in *Thesium alpinum* and *T. rostratum*, and Rao (1942) in *Santalum*, *Osyris*, *Thesium* and *Scleropyrum*, have concluded the gynaeceum to be paracarpous.

Linear tetrads of megaspores are formed as a regular feature in all the plants of Santalaceae studied so far (see Guignard, 1885; Iyengar, 1937; Rutishauser, 1937; Schaeppi and Steindl, 1937; Rao, 1942). The report of Modilewski (1928) on *Thesium intermedium* and of Schulle (1933) on *T. montanum* that the tetrads of megaspores are not formed and the megaspore mother cells directly give rise to tetrasporic embryo sacs developed after 'Lilium Type' ("Adoxa Type" of Maheshwari, 1948, 50), cannot be held as correct. It may be pointed out here that in *Thesium* species some of the mother cells are arrested in growth and may be seen present in an ovule which has developed upto megaspore tetrad stage and in which the development of the female gametophyte has started (see Fig. 203). In such cases if somehow the non-functional megaspores capping the young embryo sac are missed one is liable to erroneously conclude that the embryo sac has developed directly from a megaspore mother cell. The chalazal member of the tetrad of megaspores functions to form the embryo sac, while the micropylar ones are non-functional. Rao's (1942) report that in *Santalum album* the micropylar megaspore functions, does not appear to be correct and is probably based on a misinterpretation of the antipodal cells as non-functional megaspores. In *Thesium* species, the non-functional megaspores may not degenerate early but develop megaspore haustoria somewhat similar to those found in certain members of Rubiaceae (Fagerlind, 1937) and Crassulaceae (Mauritzon, 1933).

A very peculiar feature found in *Santalum* and *Osyris* is the micropylar elongation of the embryo sac at four-nucleate stage. In *Santalum* this growth is most excessive so that the micropylar tip of the embryo sac protrudes out of the ovule and grows up in the ovary cavity towards the stylar canal. Thus the micropylar end of the embryo sac which originally pointed down in the ovary, ultimately points up and occupies a higher position in ovary cavity. The egg apparatus is organised at the tip of the free arm. In *Osyris* the elongation of the four-nucleate embryo sac is comparatively much less so that it does not protrude out of the ovule at this stage. However, in *Osyris*, as well as *Thesium*, the micropylar end of the mature embryo sac crushes the top of the ovule and lies out of it. In *Philadelphous* (Mauritzon, 1933), *Utricularia* (Kausik, 1938), certain members of Rubiaceae (Fagerlind, 1937) and Scrophulariaceae (Krishna Iyengar, 1940, 1941) and several other plants of diverse families (see Maheshwari, 1948, 50), the micropylar end of the embryo sac harbouring the egg apparatus protrudes out of the ovule and lies free in the ovary cavity.

The condition in Balanophoraceae also is quite interesting. In *Balanophora* the tip of the embryo sac, which is destined to harbour the egg apparatus, faces down in the flower in earlier stages (see Ekambaram and Panje, 1935; Fagerlind, 1937). But at two-or four-nucleate stage a tubular outgrowth starts from this end of the embryo sac and grows upward. Thus the egg apparatus end ultimately lies at a higher level than the antipodal end of the embryo sac. This is quite similar to what happens in *Santalum*, with the difference that in *Balanophora* the ovary cavity has been completely obliterated and no distinct mamelon is formed. Thus the embryo sac grows embedded in the tissue of ovary.

In Loranthoideae also the elongation of the egg apparatus end of the embryo sac is a very characteristic feature. Here the tip of the embryo sac facing up in the flower begins to grow straight upward in the carpellary tissue to enter the style, and the egg apparatus is organised quite up at this end (Rauch, 1936; Schaeppi and Steindl, 1942; Maheshwari and Johri, 1950; Maheshwari and Singh, 1952; Singh, 1952). It should, however, be clearly distinguished that in *Santalum* and *Balanophora* the tip of the embryo sac which is facing down in the flower, takes a turn and begins to grow upward while in Loranthoideae the tip which is pointing up in the flower begins to grow straight upward. This is especially important in such members of Loranthoideae like *Elytranthe*, *Macrosolen* etc., which are characterised by the presence of a three lobed mamelon (Schaeppi and Steindl, 1942; Maheshwari and Singh, 1952), similar to that found in some Santalaceae. Maheshwari and singh (1952; p. 28) discussing the structure of the mamelon write, "The lobes of the mamelon of *Macrosolen*, which we have interpreted as ovules, do not show any differentiation into nucellus and integument. There is therefore nothing which can be designated as the micropyle, but if the analogy with *Thesium* (Fagerlind, 1945) is correct, it is the side towards which the hypodermal archesporium differentiates which must be considered as micropylar." It would mean that the micropylar side of the ovule in *Macrosolan* is pointing downward, just as in *Santalum* and *Thesium*. This would then imply that in *Macrosolen* and also *Elytranthe* this is the chalazal tip of the embryo sac which is pointing, up, elongates upward and the egg apparatus is organised at this end, while the antipodals at the other end which is micropylar. Thus either in all these members of Lroanthoideae the embryo sacs have to be considered as showing a reversed polarity as a regular feature or the analogy of the micropylar and the chalzal side of the lobes of the mamelon of Loranthoideae with that of *Santalum* and *Thesium* has to be given up. If the latter case is true it would not be easily possible to explain the derivation of the reduced mamelon of Loranthoideae from some Santalaceae as has been done by Fagerlind (1945). In this respect the members of tribe Viscoideae like *Korthalsella* and *Viscum* resemble more the condition found in *Santalum*. Here the lower end of the four-nucleate embryo sac bends out of the papilla and grows upward in the carpellary tissue and the egg apparatus is organised at this end (Rutishauser, 1935, 1937; Steindl, 1935; Schaeppi and Steindl, 1945).

The formation of a chalazal embryo sac haustorium is yet another characteristic feature of Santalaceae, and has been reported by all the workers on these genera. However, they all considered it to be a direct elongation of the antipodal end of the embryo sac. The present author has been able to show very clearly with the help of microdissections of the embryo sacs that the chalazal embryo sac haustorium develops as a lateral caecum and the antipodals are left in a small pouch *in situ*. In the allied family Loranthaceae such lateral chalazal caecum was first described only in *Macrosolen cochinchinensis* (Maheshwari and Singh, 1952). The chalazal embryo sac haustorium is quite common in Centrospermales (Oksijuk, 1927; Artschwager and Starrett 1933., Joshi, 1936; Cooper, 1949), and several other angiosperms (see Finn, 1936; Maheshwari, 1950).

The micropylar as well as the chalazal embryo sac elongation apparently appear to be a device for increasing the absorptive surface of the embryo sac, to obtain the nutrient material from the surrounding tissue (see Maheshwari, 1948, 50). In *Santalum*, however, it has been suggested that the anterior elongation of the embryo sac, which carries the egg apparatus towards the stylar canal, is a device to facilitate fertilization by bringing the egg in vicinity of the pollen tube. (Griffith, 1844; Rao, 1942) A similar view was propounded by Benson (1894) for Amentiferae.

In *Osyris*, where the mature ovule along with its funiculus is 'U' shaped and points upward, the mature embryo sac along with its chalazal caecum acquires the shape of the letter 'N' or depending upon the direction in which the ovule has curved (see Fig. 140). In *Santalum* the ovule is very much reduced and is simply represented as downwardly pointed lobe of the mamelon. But the embryo sac which has retained its habit of curving upward, comes out of the ovule and curves to grow upward, so that it finally acquires a shape similar to that found in *Osyris*. This clearly indicates that *Santalum* represents a reduced condition. Smith and Smith's (1942 b) conclusion that *Santalum* is more primitive than *Osyris*, and the latter represents a side line of development from *Santalum*, as shown by their floral anatomy, does not appear to be acceptable.

In *Thesium*, which belongs to the other group Thesieae, the embryo sac shows no excessive outgrowth and upward curvature of its micropylar tip. The mature embryo sac in this genus thus remains inverted 'J' shaped.

Endosperm and Embryo.—The endosperm formation is also quite characteristic in this family. The first division of the primary endosperm nucleus is followed by the formation of a transverse wall which divides the embryo sac into an anterior and a posterior compartment. The latter acts as the chalazal endosperm haustorium, which has been reported by almost all the workers on this family. The further development of the endosperm, which is confined to anterior compartment only, is cellular, except in *Santalum* where it is free-nuclear. Thus in this plant the endorsperm development on the whole follows "Helobial type" while in *Osyris* and *Thesium* it is of "Cellular type."

The free-nuclear or cellular divisions of the endosperm have usually been considered to depend upon the spatial conditions in the embryo sac. Thus long and narrow embryo sacs are supposed to have cellular, while broad and short embryo sacs a nuclear endosperm. Maheshwari (1950) does not agree with this correlation between the size of the embryo sac and the type of endosperm divisions. The present observations in Santalaceae also support Maheshwari's (1950) view. In *Santalum*, where the anterior compertment is much long and narrow (see fig. 85) the divisions in the endosperm are nuclear, while in *Osyris* and *Thesium*, where this compartment is comparatively much broader and shorter (see Figs. 141-143, 217-224), the endosperm divisions are cellular. It appears that nuclear divisions in the long and narrow anterior compartment of *Santalum* are more advantageous because the endosperm nuclei can reach more quickly in the vicinity of the zygote which is placed quite high up at the upper end of this compartment.

In *Santalum* the endosperm formation starts in that part of the embryo sac which is lying outside the ovule in the ovary cavity. In *Osyris* and *Thesium* it starts in the premises of the ovule, but the ovular tissue is soon crushed by the growth of the endosperm, which thus lies free in the ovary cavity. Naturally in all the genera of Santalaceae there is no formation of seed coat and endosperm and embryo are directly coverd by the fruit wall.

In *Osyris* and *Thesium* usually the endosperm is formed in only one embryo sac of one of the three ovules. In *Santalum*, on the other hand, the endosperm formation may start in two or three embryo sacs belonging to different ovules. At maturity the endosperm tissue of different embryo sacs fuses with each other to form a composite structure. Such composite endosperm has so far been reported only in the members of the Loranthaceae (see Rauch, 1936; Maheshwari and Singh, 1952; Singh, 1952).

In *Osyris* and *Santalum* the egg apparatus end of the mature embryo sac points upward in the ovary cavity. Therefore, the embryo naturally points down in the fruit. In *Thesium* species where the egg apparatus end of the sac points downward, normally the embryo should be expected to point upward in the fruit. But the zygote (or the young embryo) is shifted from its original place, to occupy a reverse position in the anterior compartment of the embryo sac. Thus the embryo finally points down in the fruit, just as in other genera of Santalaceae.

Phylogenetic relationships.—There has not been uniformity of opinion about the systematic position of the order Santalales. Bessey (1915) placed the families of this order high up in his Celastrales, deriving them from Rosaceous ancestors. Similarly Pool (1941) has also considered them as a member of Celastrales, while Hutchinson (1926) regards them as derivatives of this order. Engler and Prantl (1935) have placed Santalales in Archichlamydeae, near Proteales. Rendle (1938) and Lawrence (1951) are also of the same opinion.

Schnarf (1931) in his "Vergleichende Embryologie der Angiospermen" has described Santalales near Proteales, while Johansen (1950) in his book "Plant Embryology", near Celastrales.

Smith and Smith (1942 b) have concluded on the basis of a comparative study of floral anatomy of Santalales that there is no evidence indicating its origin from either Proteales or Celastrales. They further add, "At present it seems most likely that the Santalales constitutes a separate line of development and probably has not given rise to other orders. Whether this line originates from the Celastrales, the Proteales, or from some other order, remains to be determined."

TABLE I: Comparison of important embryological features of Santalaceae with Proteales, Celastrales and Rubiaceae.

Embryological features	Proteales	Celastrales	Rubiaceae	Santalaceae
1. Anther tapetum	....	Glandular	Glandular and amoebid	Glandular
2. Quadripartition of microspore mother cells	Simultaneous	Simultaneous	Simultaneous	Simultaneous
3. Mature pollen grains	....	Bi-celled	Tri-celled	Bi-celled, also tri-celled.
4. Ovule	Crassinucellate; bitegmic; well developed micropyle.	Crassinucellate; uni, as well as bitegmic; well developed micropyle.	Tenuinucellate, unitegmic; in some cases integument completely fused with the reduced nucellus, so that no micropyle is formed (e.g. *Haustonia*).	Tenuinucellate; unitegmic, integument always completely fused with reduced nucellus so that no micropyle is formed. A very rudimentary micropyle is present in *Thesium*.
5. Female sprogenous tissue.	Single archesporial cell; parietal cells are formed.	Single archesporial cell; parietal cells are formed.	Usually many celled archesporium; no parietal cells are formed.	Many celled archesporium no parietal cells are formed.
6. Megasporogenesis.	Tetrads of megaspores formed.	Tetrads of megaspores formed.	Tetrads of megaspores are formed; non-functional megaspores form haustoria (e.g. *Galium*).	Tetrads of megaspores are formed. In *Thesium* non-functional megaspores form haustoria.

TABLE I:

Embryological features	Proteales	Celastrales	Rubiaceae	Santalaceae.
7. Embryo sac	Monosporic, eight-nucleate; follows 'Polygonum' type. Sometimes the micropylar tip of the embryo sac protrudes in the micropyle after breaking through the nucellus.	Monosporic, eight-nucleate; embryo soc remains confined to the ovule.	Monosporic, eight-nucleate; follows 'Polygonum' type. In some cases the embryo sac comes out of the ovule.	Monosporic, eight-nucleate, follows 'Polygonum' type. The micropylar end of the embryo sac crushes the ovular tissue and lies free in the ovary cavity.
8. Haustorial structures.	No.	No.	The antipodal cells elongate to form vigorous haustoria.	Chalazal embryo sac haustorium develops as a lateral caecum. Synergid haustoria also present in *Santalum*.
9. Endosperm	Nuclear	Nuclear as well as cellular	Nuclear as well as cellular.	Cellular, except in *Santalum* where Helobial
10. Endosperm haustoria	No.	No.	No.	Chalazal as well as upper micropylar endosperm haustorium present.
11. Seed	Albuminous	Albuminous; Brightly coloured ailr present.	Very rich in endosperm.	Fruit full with endosperm.

The embryological data on Santalaceae also do not appear to indicate its close alliance with either Proteales or Celastrales. For the sake of comparison their important embryological features, which are of taxonomic significance (Maheshwari, 1950), have been tabulated above. The family Rubiaceae has also been included in this comparison, because a reference to its embryological literature reveals that it resembles Santalaceae in a number of important features.

It is quite clear from the above table that the condition of the ovule and integument, the extent of female sporogenous tissue, the behavior of the mature embryo sac and the development of endosperm in Santalaceae, differ to a great extent from that found in Proteals or Celastrales. The protrusion of the tip of the embryo sac out of micropyle in Proteales is, however, an important feature which is also present in Santalaceae. But this single feature is insufficient to warrant a strong relationship between them, in presence of so many other more improtant differences.

Schellenberg (1932) is of the opinion that a taxon consisting of some families of parastic plants cannot be a relatively primitive one. Eames (1951) has recently remarked that evidences from all the sources indicate that Santalaceae occupies a relatively advanced position in the dicotyledonous group. It has already been pointed out that the extremely reduced condition of the ovules in Santalaceous genera also shows their highly advanced nature.

There is, however, some similarity in the embryological features of Santalaceae and Rubiaceae (as shown in the table). The extreme reduction of the nucellus, the fusion of the integument with the reduced nucellus, the presence of megaspore haustoria, the peculiarities of the embryo sac elongation, are some of the features which indicate a somewhat parallel development. It should, however, be kept in mind that Santalaceae consists of parasitic plants while Rubiaceae of autotrophic ones.

The order Santalales is generally divided into two sub-orders; (1) Santalineae and (2) Loranthineae; of which the first consists of six families *viz.* Olacaceae, Opiliaceae, Octoknemataceae, Grubbiaceae, Santalaceae, and Myzodendraceae, while the second has a single family Loranthaceae (Harms, 1935*). Opiliaceae and Octoknemataceae are considered by several workers to be very much alike to Olacaceae and have not been treated speparately (Schellenberg, 1932; Sleumer, 1935*; Smith and Smith, 1942 b; Lawrence, 1951). Recently Fagerlind (1948) has suggested that Opiliaceae with a single ovule in its ovary, is much more advanced than Olacaceae and has been derived from tribe Thesieae of Santalaceae. He, therefore, recommends that Opiliaceae should be separated from Olacaceae and joined with Santalaceae.

Hutchinson (1926) considers the arrangement of families in Santalales to be Loranthaceae, Santalaceae, Grubbiaceae, and Myzodendraceae. Schellenberg (1932) has laid special stress on the extent of parasitism and the condition of the ovule as more important characters which indicate the trend of advancement in Santalales. Thus on the basis of increasing parasitism and reduction in the complexity of the ovule, he considers the Olacaceae to be more primitive and the Loranthaceae to be more advanced than Santalaceae, the latter representing an intermediate condition between the two. Harms (1935*), Sleumer (1935*), Rendle (1938), Smith and Smith (1942 b), Fagerlind (1948), Lawrence (1951) have all agreed with Schellenberg (1932) in as much as the arrangement of these three families is concerned.

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*See Engler and Prantl (1935)

Smith and Smith (1942 b), on the basis of evidence obtained from a comparative study of floral anatomy consider *Strombosia* of Olacaceae to be the probable ancestor, which might have given rise to a primitive form of Santalaceae. From this primitive plant three separate lines have developed repreenting the three tribes of Santalaceae, *viz.*, Anthoboleae, Osyrideae, and Thesieae (Smith and Smith, 1942 b, p. 64). Fagerlind (1948) also is of the opinion that there are at least two lines of development in Santalaceae and the separation of Osyrideae and Thesieae as distinct tribes is quite natural. The present embryological studies in *Osyris*, *Santalum* and *Thesium* also justify their separation in two tribes.

It may be pointed out here that there is a considerable difference of opinion between Smith and Smith (1942 b) and Fagerlind (1948) about the position of different genera in each tribe. To cite an example, Smith and Smith (1942 b) consider *Arjona* to be the most advanced genus in tribe Thesieae. Fagerlind (1948) on the other hand considers that *Arjona* represents the most primitive condition in Santalaceae, as evidenced by its gynaecum morphology which is quite similar to *Aptandra* of Olacaceae. It has already been pointed out by the present author that Smith and Smith's (1942 b) conception of primitive or advanced nature of different genera on the basis of floral anatomy only, without considering the morphology of the floral parts, especially the gynaeceum, does not appear to be very sound. Morphological and embryological data on a number of genera of all the three tribes of Santalaceae should be collected to draw a correct phylogenetic scheme.

SUMMARY

The floral parts arise in a regular sequence. The ovary wall and the mamelon pimordia differentiate simultaneously. Perianth is gamophyllous in *Santalum* and *Thesium*, and the seemingly polyphyllous condition in *Osyris* is the result of fusion of the gamophyllous region of the floral tube with the ovary wall. The vascular supply to the perianth lobes indicates towards their sepaloid nature. The ovary is unilocular. The depressions found at the base of the ovary cavity in *Osyris* and *Santalum* are formed only in later stages and do not represent true locules. In *Osyris* there is a clear indication of solidification of the lower part of ovary.

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* See Engler and Prantl (1935).

The ovary cavity is occupied by a mamelon, which represents the free-central placenta along with three ovules developed near its tip. The placenta is mainly carpellary in its peripheral part with a central core of axial tissue incorporated in its base.

In *Santalum* the elongated beak of mamelon, which is formed by the chalazal growth of the ovules along with the placenta, extends into the stylar canal. The ovary, therefore, appears only semi-inferior in this genus, while inferior in others.

In *Thesium* a few abnormal female flowers were observed in which placenta had elongated in the stylar canal and ovules were borne on it at different levels in this region.

Vascular supply of the flower is very much complicated. The strands forming the ventral carpellary supply appear to be recurrent for some distance due to a localised differential growth of the receptacle in its inner regions. Some vascular tissue is found in the pith region at the base of the flower. This tissue is a continuation of the recurrent traces, and has been interpreted as the residue of the ventral carpellary supply. The inferior ovary wall is mainly receptacular in *Santalum,* while receptacular below and appendicular above in *Osyris*. In *Thesium* the vascular supply does not give any sure indication of the nature of the ovary wall.

The anther wall is formed of an epidermis, an endothecium, one middle layer in *Osyris* and *Thesium* while two to three middle layers in *Santalum;* and one layer of tapetum. But in *Osyris* and *Santalum,* however, two to three tapetal layers are observed in later stages. The tapetal cells are multinucleate, except in *Osyris* where they remain uninucleate throughout.

In *Thesium* the fibrous thickenings of the endothecial cells develop in a characteristic stellate pattern.

In *Santalum* the epidermis of the anther is very much cuticularised and cutinised and persists even in a mature anther.

Microspore mother cells are surrounded by a thick hyalline wall. Their division takes place simultaneously to produce tetrahedral or isobilateral tetrads of microspores.

In *Santalum album* cytomixis is observed between microspore mother cells, dyads or even tetranucleate cells. Sometimes less than four or more than four microspores are also formed surrounded by a mother cell wall.

In *Thesium* all the microspores are functional and develop into mature pollengrains. In *Santalum* a number of microspores are arrested in growth and degenerate. In *Osyris* all the microspores or uni-nucleate pollen grains are arrested in growth and degenerate so that not a single viable and mature pollen grain is formed in a seemiugly hermaphrodite flower, which is thus male-sterile.

In *Santalum* the pollen grains germinate *in situ* at bicelled stage. Failing this tricelled pollen grains are also formed.

In *Osyris* the ovule, along with its funiculus, is 'U' shaped, with the free tip of the ovule pointing up in the ovary. In *Santalum* and *Thesium*, on the other hand, they are represented as downwardly pointed lobes of the mamelon.

In all the genera the presence of an integument has been demonstrated, which, however, remains fused with the reduced nucellus. In *Thesium* the integumentary tissue bulges slightly above the nucellus, and thus a rudimentary micropyle is formed.

The female archesporial cells directly function as megaspore mother cells. They give rise to linear tetrad of megaspores, of which the chalazal member functions.

In *Thesium* the micropylar non-functional megaspore also elongates to form a haustorial structure, which penetrates through the micropyle to come out in the ovary cavity. In *T. alpinum* in some cases all the non-functional megaspores had developed tubular haustorial structures.

In *Osyris* and *Santalum* the four-nucleate embryo sac shows an elongation of its micropylar end. In *Santalum* this tip of the embryo sac comes out of the ovule and curves to grow upward towards the style. Thus the embryo sac becomes 'U' and later 'J' shaped, by the time eight nuclei are formed in it. The egg apparatus is organised at the tip of the long and free arm of 'J', the polar nuclei lie in the bend, while the antipodal cells are organised at the other end, deep in the the ovule.

In *Osyris* and *Thesium* the swollen tip of the mature embryo sac crushes the ovular tissue and thus the egg apparatus end lies free in the ovary cavity.

A caecum, the chalazal embryo sac hauasorium, develops laterally near the antipodal end of the embryo sac, with the antipodal cells left *in situ* in a small pouch. A mature embryo sac, along with its lateral ceacum thus acquires the shape somewhat like 'N' or in *Osyris and Santalum album*, 'U' in *S. yasi* and an inverted 'J' in *Thesium*.

The chalazal haustorium becomes more aggressive in post-fertilization stages, when after devastating the tissue of the placental stalk, it penetrates deep in the tissue below the base of the ovary cavity in *Osyris* and *Santalum*. In *Thesium*, however, it does not grow beyond the placental stalk.

In *Osyris* and *Santalum* the synergids are beaked and show a distinct filiform apparatus at their upper end. In *Santalum* the tips of the synergids protrude out of the embryo sac and later develop narrow membranous and branched synergid haustoria. They persist for long during the development of embryo. In *Thesium* the synergids are not very prominent and degenerate soon after fertilization.

The first division of the primary endosperm nucleus is followed by a transverse wall, which divides the embryo sac into an anterior and a posterior compartment. The nucleus in the latter compartment functions as the chalazal endosperm haustorial nucleus. It does not usually divide further and soon gets hypertrophied.

The endosperm is formed in the anterior compartment only. In *Santalum* it is of 'Helobial' type, while in *Osyris* and *Thesium* it is cellular.

In *Santalum* the upper endosperm haustorium also develops in vicinity of the zygote when some free endosperm nuclei have reached there. In *Thesium* some of the endosperm cells opposite to the embryo become multinucleate, swell up and enlarge to carry on the haustorial function.

The endosperm tissues developing in different embryo sacs of an ovary of *Santalum* fuse to form a composite structure.

In *Santalum* the development of the endosperm starts outside the ovule, while in *Osyris* and *Thesium* the endosperm crushes the ovular tissue and comes out of it.

In *Thesium* the zygote is placed laterally in the embryo sac and with the growth of the endosperm it is pushed further laterally so that the embryo finally occupies a reverse position in the embryo sac.

The first division of the zygote is transverse to the longitudinal axis. The second division is longitudinal in both apical and the basal cells. The derivatives of both these cells take part in formation of the embryo proper. No suspensor is formed.

Only a single embryo, embedded in the massive endosperm, is formed in each fruit and points downward in all genera. As the ovule is completely crushed during the growth of the endosperm, no seed coat is formed, and the endosperm and embryo are directly covered by the fruit wall.

The separation of *Santalum* and *Osyris* in the one hand, and *Thesium* in the other, to separate tribes Osyrideae and Thesieae respectively, is justified.

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Chief Editor.

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THE GRASSES OF AGRA DISTRICT

By R. C. Bharadwaja,* *Botany Department, D. A. V. College, Muzaffarnagar,*

K. C. Basu Chaudhary & S. Sinha, *Botany Department, Agra College, Agra.*

The district of Agra is situated at 27° N.L. and 78.15° E.L. and occupies the south-western corner of Uttar Pradesh. It forms a part of the Upper Gangetic Plain. The area is mostly level ground covered by the Gangetic alluvium, except for small elevations of sandstone in the west and undulated ravine land along the course of the rivers. The rivers comprise the Yumuna, its two large tributaries, the Chambal and Uttangan and several minor streams. Climatically the area is semi-arid, as the mean annual rainfall rarely exceeds 30," most of which is received from July to September. The number of rainy days are 30-40 in a year, with fairly long breaks of dry weather. There are also fluctuations from year to year in the annual rainfall, which is sometimes quite significant.

Recently this area has received much attention in respect of afforestation. In order to check the encroachment by the Rajputana desert upon the fertile lands of Uttar Pradesh, several schemes of rehabilitation of forests have been set going. For a long term management and development of forests, the importance of study of the existing vegetation of the region cannot be overemphasized. Grasses form an important constituent of the forest flora. The indicator value of grasses is also quite important (Bor: 1947; Raizada: 1954).

The present study is based chiefly on the material collected by the authors themselves. Collections at the Herbarium of the Forest Research Institute, Dehra Dun, have also been studied. Recent works of Bor (1947), Raizada, Jain and Bharadwaja (1954) and Raizada (1954) have aroused considerable interest in the group as represented in the Upper Gangetic Plain. Bor (1947) dealt with 92 species from Uttar Pradesh. Paliwal (1935) and Watts (1953), after studying the flora of Agra have reported only 37 and 39 species of grasses respectively. The present study includes 89 species and varieties. Keys to the various taxa and full citations to the genera and species are given. Short notes on the distribution, ecology and economic importance are also appended. As far as possible, latest nomenclature has been adopted and where changes in names have occurred, the synonym as it appears in Hooker's Flora of British India Vol. VII is given. More common Sanskrit (abbreviated as Sans), Hindi and English names are also given in many cases.

Cymbopogon schoenanthus (Linn.) Spreng., *Aristida depressa* Retz., and *Digitaria biformis* Willd. subsp. *willdenowi* Retz. are reported here for the first time from the Upper Gangetic Plain.

---

*At present at National Botanic Garden, Lucknow.

The following table gives an analysis of the various taxa of Gramineae of the area:—

POOIDEAE			PANICOIDEAE		
Tribes	Number of genera	Numbre of species.	Tribes	Number of genera	Number of species.
1. Festuceae	1	1	1. Paniceae	13	29
2. Hordeae	2	2	2. Andropogoneae	18	26
3. Arundineae	2	2			
4. Eragrosteae	5	13	3. Maydeae	1	1
5. Sporoboleae	1	3			
6. Chlorideae	5	6			
7. Agrosteae	1	1			
8. Stipeae	1	2			
9. Zoysieae	2	2			
10. Oryzeae	1	1			
Total	21	33	Total	32	56

Key to Subfamilies

Spikelets 1—many flowered, breaking up at maturity above the more or less persistent glumes, (or if falling entire then not 2-flowered with the lower lemma bearing a male floret or empty and the upper lemma bearing a male floret) usually more or less laterally compressed or terete ... ... I. POOIDEAE

Spikelets 2—flowered, falling entire at maturity, (usually with the upper lemma fertile and the lower with a male floret or empty) all alike or different in size, shape and structure, frequently dorsally compressed ... ... 2. PANICOIDEAE

POOIDEAE

Some of the primitive genera show a marked reduction in the number of florets.

Key to the tribes of the Pooideae (modified from Hubbard).

A. Spikelets open or contracted, or spike-like panicles, less often in racemes or spikes and then with glume one or both suppressed if on opposite sides of a continuous rachis, or with 2 or more fertile florets if on one side of the rachis.

B. Spikelets usually with 2 or more fertile florets, or if with 1 fertile floret then with sterile floret above it.

C. Plants of moderate size; flowering culms thin upto 60 cm. high

*Lemmas 5-7 nerved ... ... 1. FESTUCEAE

*Lemmas 1-3 nerved ... ... 4. ERAGROSTEAE

CC. Tall reed-like grasses; (flowering culms thick, upto 7 m. high. ... ... 3. ARUNDINEAE

BB. Spikelets with 1 fertile floret male or female in unisexual 1-flowered spikelets with or without 1 or 2 male or barren florets below it.

D. Gls. very minute or suppressed; palea 3-9 nerved, stamens 6 ... ... 10. Oryzeae

DD. Gls. usually well developed

E. Spikelets usually breaking up at maturity, the rachilla disarticulating above the more or less persistent glumes, very rarely falling entire and then with firmly membranous, awned or 5-nerved lemmas

F. Lemmas hyaline or membranous at maturity, rarely indurated and laterally compressed. awnless or awned from low down on the back or from the entire or bifid tip

*Lemmas usually 3-5 nerved, frequently awned; gls. firmer and longer than the hyaline lemma or if shorter than the lemma, herbaceous-membranous and dull; grain usually with an adhering pericarp ... 7. Agrosteae

*Lemmas 1-3 nerved, awnless; gls. similar to lemmas in texture, hyaline or thinly membranous, shining; grain usually with a free pericarp ... ... 5. Sporoboleae

FF. Lemmas indurated and rigid at maturity, terete or dorsally compressed, with involute or convolute margins, tigtly embracing the grain, with a terminal awn ... ... 8. Stipeae

EE. Spikelets, falling entire at maturity, either singly or in clusters from the axis of the slender spike-like panicles or racemes; lemmas delicate, 1-3 nerved ... ... 9. Zoysieae

AA Spikelets sessile or subsessile along one side of the rachis of solitary, digitate or scattered spikes or spike-like racemes (with 1 fertile floret and 1-3 nerved lemmas) or on the opposite sides of the rachis of solitary spikes or racemes

* Spikelets on opposite sides of the rachis of solitary spikes 2. Hordeae

** Spikelets in one or two rows on one side of the usually continuous rachis of digitate spikes ... ... 6. Chlorideae

Tribe I. Festuceae

A tribe of mostly temperate genera, represented only by *Poa* Linn. in this area.

Poa Linn.

Poa Linn. Gen. ed. 1, 20. 1737; Hook. f. Fl. Brit. Ind. 7: 345. 1897

A large genus of annual or mostly perennial herbs occurring throughout the cooler parts of the world and on the higher mountains of the tropics.

Poa annua Linn. Sp. Pl. 68. 1753; Hook. f. Fl. Brit. Ind. 7: 345 .1897.

Taj lawns, Agra. Recently introduced in the plains of North India as a weed in green lawns. Distributed in Europe, temperate Asia, North and South America.

Tribe 2. HORDEAE

A tribe of temperate regions, containing several important cereals.

Key to the genera.

*Spikelets solitary, 2 or more-flowered	1. TRITICUM
*Spikelets in threes, 1-flowered	2. HORDEUM

1. **Triticum** Linn.

Triticum Linn. Syst. ed. 1. 1735; Hook. f. Fl. Brit. Ind. 7: 367. 1897.

About 20 species in eastern and western Asia, Mediterranean Region and Europe. Several species are under cultivation in the various parts of the world.

Triticum aestivum Linn. Sp. Pl. 85. 1753; *Triticum vulgare* Vill. Hist. Pl. Dauph. 2. 153 1787; Hook. f. Fl. Brit .Ind. 7: 367. 1897. (Sans. Godhum; Hindi Gehun; The Wheat plant).

Cultivated throughout the area, and in several parts of North India.

2. **Hordeum** (Tourn.) Linn.

Hordeum (Tourn.) Linn. Syst. ed. 1. 1735; Hook. f. Fl. Brit. Ind. 7: 371. 1897.

25 species in the temperate regions of both the hemispheres; some are cultivated.

Hordeum vulgare Linn. Sp. Pl. 84. 1753; Hook. f. Fl. Brit. Ind. 7: 371 1897; (Sans. Yav; Hindi, Jau; The Barley plant).

Cultivated throughout the area and in several parts of North India. Distributed in South East Asia and North Africa.

Tribe 3. ARUNDINEAE

Tall, perennial, reed-like grasses inhabiting moist localities near water courses, banks of the rivers and ponds within the area and elsewhere.

Key to the genera

A. Lemmas glabrous; rachilla bearded	1. PHRAGMITES
AA. Lemmas with silky hairs on back	2. ARUNDO

1. **Phragmites** Trinius

Phragmites Trins. Fund Argost. 134, 1820, Hook. f. Fl. Brit. Ind. 37: 30. 1897.

A small genus of only 3 species, one in Argentina, one in Tropical Africa and one cosmopolitan.

Phragmites maxima (Forsk.) Chiov. in Nuov. Giom. Bot. Ital. 26: 30. 1919; *P. communis.* Trin. Fund. Agros. 7: 134. 1820; Hook. f. Fl. Brit. Ind. 7: 303. 1897; *P. karka* Trin. ex. Steud. Nom. ed. 2 : 234. 1841; Hook. f. ibid. 304.

Common along the river banks throughout the area. Distributed from India to Burma and Ceylon.

It is a perennial hygrophilous tall grass with an underground thick rhizome. It thrives best in marshes and flowers after the rains. Culms are used for thatching, mat-making, screens, sticks, baskets, arrow shafts etc. Recently paper mannfacture has also been tried.

2. **Arundo** Linn.

Arundo Linn. Sp. Pl. 81. 1753; Hook. f. Fl. Brit. Ind. 7: 302. 1897.

A small genus of 12 species occurring in tropical and temperate regions of the world.

Arundo donax Linn. Sp: Pl. 81. 1753; Hook. f. Fl. Brit. Ind. 7:302. 1897. (The Giant Reed).

We have seen some plants growing along the banks of the Utangan river and in Bund-Baretha (Bharatpur); likely to occur in similar other localities within the area. Distributed in the lower Himalayas, the Punjab, Assam and Nilgiri Hills; also in North Asia, N. Africa and Europe.

A perennial, hygrophilous, tall grass with an underground creeping rhizome. Under cultivation it can do well in comparatively dry soils. Some variegated varieties are cultivated in the gardens as an ornamental. Paper manufacture has also been tried. Flowers after the rains.

Tribe 4. ERAGROSTEAE

Annual or perennial herbs. Spikelets 2 to many flowered, usually laterally compressed, pedicellate or sessile. Glumes and lemmas more or less similar in appearance.

Key to the genera

A. Spikelets sessile or subsessile
  + Inflorescence of digitate spikes
    * Axis of the spike terminating in a spkelet ... 1. ELEUSINE
    ** Axis of the spike terminating in a mucro ... 2. DACTYLOCTENIUM
  + + Inflorescence not of digitate spikes
    * Inflorescence very coarse, 15-45 cm. x 1. 3-3.8 cm.,

	narrowly pyramidal or columnar, often interrupted; spikelets pale-brown	3. DESMOSTACHYA
	** Inflorescence of filiform spikes; spikes upto 10 cm. long or longer; spikelets not pale brown ...	4. LEPTOCHLOA
AA	Spikelets pedicellate	5. ERAGROSTIS

1. **Eleusine** Gaertner

Eleusine Gaertn. Fruct. 1: 7, t. 1. 1788; Hook. f. Fl. Brit. Ind. 7:293. 1897 (in part).

A small genus of only 10 species, occurring in the tropical sub-tropical regions of Asia and Africa.

Key to the species

A.	Plants erect	
	* Spikes digitate	1. E. INDICA
	** Spikes scattered or whorled	2. E. VERTICILLATA
AA.	Plants creeping and rooting at nodes	3. E. FLAGELLIFERA

1. *Eleusine indica* Gaertn. Fruct. 1 : 8. 1788; Hook f. Fl. Brit. Ind. 7: 293. 1897.

Throughout the area and fairly common in rainy season. Distributed in the Upper Gangetic Plain, Bihar, Bengal, Cutch, Bombay and Madras States; also in tropical countries of the Old World.

"It is a sporadic annual which often appears in quantity on cultivated ground where it grows with great rapidity, sending up numerous flowering shoots from a fleshy prostrate base. Being an annual it appears with the onset of the rains and dries up quickly if on dry soil. On richer and moist soils it remains green for a longer period"—Bor (1947). It is said to be good fodder grass, the nitrogenous content being large. Sometimes seeds are used in times of scarcity.

2. *Eleusine verticillata* Roxb. Fl. Ind. 346. 1832; Hook. f. Fl. Brit. Ind. 7 : 295. 1897.

Kailash and Sikandra, in fields, not common. Distributed throughout the tropics of the Old World.

It is good for cattle and can be stacked for 12-15 years.

This grass should be called *Acrachne racemosa* (Heyne) Ohwi.

3. *Eleusine flagellifera* Nees in Linnaea 16:220. 1842; Hook. f. Fl. Brit. Ind. 7: 294. 1897.

Common throughout the area particularly in Jumna ravines. Distributed in Punjab, the upper Gangetic Plain, Cutch and Bombay; also in Afghanistan and North Africa.

The grass prefers sandy desert tracts. It sends runners in various directions and thus can bind sandy soil. It can also thrive in clayey and saline soils. This grass is especially liked by donkeys and can be stacked for 9-10 years.

2. **Dactyloctenium** Willdenow

Dactyloctenium Willd. Enum. Pl. 1029. 1809; *Eleusine* Hook. f. Fl. Brit. Ind.7: 295. 1897 (in part).

A small genus of 5 species chiefly in warmer regions of the world. *Dactyloctenium aegyptium* (Linn.) Beauv. Ess. ag Agrost. 72. 1812; *Eleusine aegyptiaca* Desf. Fl. Atlant. 1:85. 1798; Hook. f. Fl. Brit. Ind. 7:295 .1897.

Very common throughout the area. Some browsed plants assume peculiar depauparated and prostrate form. Distributed in the Punjab, Upper Gangetic Plain, Bihar, Bengal, Assam, Sind, Saurashtra, Bombay and Madras; also in other tropical and sub-tropical countries of the world.

It thrives on poor dry soil and particularly in waste lands but is also found in cultivated fields. It is a good fodder grass. The seeds yield flour which can make chappatis and eaten in times of scarcity. A decoction of the grains and green parts is used in Africa for curing kidney pains and ulcers.

3. **Desmostachya** Stapf.

Desmostachya Stap. in Fl. Cap. 7:632. 1897; *Eragrostis*. sect. *Desmostachya* Hook. f. Fl. Brit. Ind. 7:324. 1897.

It is a monotypic genus distributed from India to Syria and Africa.

Desmostachya bipinnata (Linn.) Stapf. in Dyer's Fl. Cap. 7. 632. 1897; *Eragrostis cynosuroides* Beauv. Agrost. 71. 162,1812; Hook. f. Fl. Brit. Ind. 7. 324. 1897.

Agra, in sandy fields, frequent. Distributed in the Punjab, the Upper Gangetic Plain, Bihar, Madhya Pradesh, Sind, Saurasthra, Bombay and Madras States.

A perennial stoloniferous grass growing in deserts and flowers during the rains. It is said to be a good desert fodder grass, but cattles generally do not like it. Fibre is used for making ropes. Among Hindus this grass is regarded sacred and dead bodies are laid upon a mat made of it. It is also used in certain other ceremonies especially the "Shradh."

4. **Leptochloa** Beauvois

Leptochloa Beauv. Agrost. 71, t. 15 f. 1. 1812; Hook. f. Fl. Brit. Ind. 7:297. 1897.

This genus is closely allied to *Diplachne* of the tribe Festuceae. Some agrologists like Hitchcock sink *Diplachne* in *Leptochloa*.

Species about 15, in the tropical and subtropical regions of the world.

Key to the species

A. Spikelets 2-3 flowered, less than 2.5 mm. long ... 1. L. PANICEA

AA. Spikelets 4-6-flowered, 2.5 mm. or more long. ... 2. L. CHINENSIS

1. *Leptochloa panicea* (Retz.) Ohwi in Bot. Mag. Tokyo. 4:311. 1941; *L. filiformis* R. & S. Syst. 2:580. 1817; Hook. f. Fl. Brit. Ind. 7. 298. 1897.

Khandari Farm, Agra; also at Bund-Baretha (Bharatpur). It is a sporadic grass of the area, nowhere common. Distributed throughout India, tropical Asia and America.

It is a weed of cultivated fields.

2. *Leptochloa chinensis* (Linn.) Nees, in Syll. Ratisb. 1:4. 1824; Hook. f. Fl. Brit. Ind. 7:299. 1897.

Near Poiya Ghat in fields. It is a rare grass of the area, and may be regarded as a robust form of the previous species. Distributed throughout the tropical Asia, Africa and Australia.

5. **Eragrostis** Beauvois

Eragrostis Beauv. Ess. Agrost. 1812; Hook. f. Fl. Brit. Ind. 7:312. 1897. (excluding sections *Desmostachya* Stapf and *Plagiostachya* Benth.)

A large genus of 250 species mostly in warmer regions of the world.

Key to the species

A. Rachilla of spikelets jointed and breaking up from above downwards.
  B. Spikelets 2.5 mm. long; panicle short, compact cylindric, 2-4 cm. long ... ... 1. E. CILIARIS
  BB. Spikelets 2.5-4 mm. long; panicles 5-20 cm. long
    * Grains ovoid; stamens 3 ... ... 2. E. TENELLA
    ** Grains obovoid; stamens 2 ... ... 3. E. INTERRUPTA
AA. Rachilla of spikelets tough, persistent; lemmas falling away from its base upwards
  B. Leaf margins glandular ... ... 4. E. POAEOIDES
  BB Leaf margins eglandular
    * Spiketets 2.5 cm. long or more, narrowly linear; branches of panicle solitary 5. E. TREMULA
    ** Spiklets small, 0 .4 cm. long or less ... 6. E. PILOSA

1. *Eragrostis cilliaris* (Linn.) R. Br. in Tuckey, Narr. Exp. Congo App. 478. 1818; Hook. f. Fl. Brit. Ind. 7:314. 1897.

Kitham & Bah, in fields. A sporadic grass of the area occurring in sandy fields. It is easily distinguished from other species by its compact cylindrical inflorescence. Distributed throughout India; also in Arabia, tropical Africa and America.

It is a good fodder.

2. *Eragrostis tenella* Beauv. ex R. & S. Syst. 2:576. 1817; Hook. f. Fl. Brit. Ind. 7:315. 1897.

Very common in waste and cultivated grounds during rains and in winter. Distributed throughout the Upper Gangetic Plain; also in other parts of India and Ceylon.

It is a rich grass capable of being made into hay.

3. *Eragrostis interrupta* Beauv. Agrost. 71. 1812; Stapf in Hook. f. Fl. Brit. Ind. 7:316. 1897.

NB. For synonymy and varieties see Blatter and McCann (1935). Authors follow Blatter and MacCann in dropping all the varieties of Stapf.

Sikandra and Kiraoli, in sandy places, sporadic, rare. Distributed in the Indo-Gangetic Plain, Bombay, Madras and Assam; also in Ceylon, tropical Asia and Africa.

It is generally found on heavy soils and is very variable in habit. Only buffaloes like this grass.

4. *Eragrostis poaeoides* Beauv. Ess. Agrost. 162. 1812; E. *minor* Host, Gram. Austr. 4:15. 1809; Stapf in Hook. f. Fl. Brit. Ind. 7:321. 1897.

Common in fields during the rains and winter. Distributed throughout India, Afghanistan and tropical Africa.

5. *Eragrostis tremula* Hochst. ex. Steud. Syn. Gram. 269. 1854; Hook. f. Fl. Brit. Ind. 7:320. 1897.

Hewett Park, in lawns, not common. Distributed in the Upper Gangetic Plain, Bihar, Bengal, Assam, Madras, Cutch, Kathiawar and the Western Ghats.; also in Afghanistan and tropical Africa.

Prefers light sandy soils. It is said to be a good fodder grass, but the foliage yield is small.

6. *Eragrostis pilosa* (Linn.) Beauv. Ess. Agrost. 71. 1812 ; Hook f. Fl. Brit. Ind. 7:323. 1897.

Common throughout the area. Distributed all over India, also in South Europe and most warm countries.

Grows well in damp moist soil but not in water-logged habitat. It is used as a fodder, particularly for buffaloes.

Tribe 5. **Sporoboleae**

Glumes and lemmas similar; floret 1; rachilla disarticulating above the glumes. Annual or perennial herbs.

Sporobolus R. Brown

Sporobolus R.Br. Prodr. 169. 1810; Hook. f. Fl. Brit. Ind. 7:247. 1897.

Species about 90 mostly perennial; distributed in America and the warm regions of the world.

Key to the species

A. Gls. shorter than the lemma ... ... 1. S. DIANDRUS.
AA. Gl. I shorter than Gl. II and lemma
  B. Panicle contracted ... ... 2. S. ORIENTALIS
  BB. Panicle effuse; spikelets 2.5 mm. long ... ... 3. S. PALLIDUS.

1. *Sporobolus diandrus* (Retz.) Beauv. Ess. Agrost. 25. 1812; Hook. f. Fl Brit. Ind. 7:247. 1897.

Common within the area. Distributed throughout India, Ceylon, Asia and Australia.

Grows on a variety of soils. "When the leaves are young, cattle eat this grass very eagerly, but do not seem to care for it when the leaves become old. However by frequent grazing it can be made to produce young leaves in succession. This grass is also an excellent soil binder, as its roots form a perfect matting in any kind of moist soil after planting. This is very difficult to eradicate when once established"—Achariyar and Mudaliyar (1921).

2. *Sporobolus orientalis* Kunth. Enum. pl. 1:211. 1838; Hook. f. Fl. Brit. Ind. 7:251. 1897.

Usar plantation, Etawah, Duthie (Herb. Dehra). Possibly also within our area. Distributed throughout the Punjub, Uttar Pradesh, Cutch, Gujerat, Bombay, Madras and Ceylon.

Prefers dry, sandy or saline soils. It is said to be a good fodder grass.

3. *Sporobolus pallidus* Boiss. Fl. Orient. 5:514. 1884; *S. arabicus* Boiss. Diagn. Pl. Orient. II, 13, 47. 1853; Hook. f. Fl. Brit. Ind. 7:252. 1897.

Jumna ravines of Agra and Itmadpur, Duthie (Herb. Dehra.). Distributed in the Punjab. Uttar Pradesh, Rajasthan, Sind also in Baluchistan, Afghanistan and Arabia.

Tribe 6. CHLORIDEAE

Spikelets usually compressed, 1-few flowered, arranged in one or two rows on one side of the rachis; lemmas membranous to chartaceous, entire. Annual or perennial grasses.

Key to the genera

A. Spike solitary,
  B. Spikelets half immersed in the alternating distichous cavities of the rachis of the spike ... ... 1. OROPEITUM
  BB Spikelets not so as in B:—
    C. Gl. I elongate-subulate ending in a rigid scabrid awn; lower lemma ovate-lanceelate, awned from the bidentate apex ... ... 2. MELANOCENCHRIS
    CC. Gl. 1, narrow, keeled, membranous, acute lower lemma obovte, awned from the back below at the apex. 3. TETRAPOGON
AA. Spike digitate
  D. Spikelets awnless ... ... 4. CYNODON
  DD Spikelets awned ... ... 5. CHLORIS.

1. **Oropetium** Trinius

Oropetium Trin. Fund. Agrost. 98. t. 3. 1820; Hook. f. Fl. Brit. Ind. 7:366. 1897.

A small genus of only 6 species, occuring in India, Ceylon, Algeria and South Africa.

Oropetium thomaeum (Linn.) Trin. Fund. Agrost. 98. t. 3. 1820; Hook. f. Fl. Brit. Ind. 7:366. 1897.

Jumna ravines near Kailash. Distributed in the Upper Gangetic Plain, Bihar, Bombay, and Madras; also in Ceylon.

A xerophytic grass, preferring old ravines, walls and similar other dry localities. It is a very short lived monsoon plant.

2. **Melanocenchris** Nees

Melanocenchris Nees. Proc. Linn. Soc. 1:94. 1841; *Gracilea* Koen. ex/ Rottl. in Ges. Nat. Fr. Neue. Sehr. 4:218. 1803; Hook. f. Fl. Brit. Ind. 7:283. 1897.

A small genus of only 2 species, found in India Arabia and Africa.

Melanocenchris jacquomontii Jaub. & Spach. III. pl. Or. 4:36, 325, 1850-53; *Gracilea royaleana* Hook. f. Fl. Brit. Ind. 7:284. 1897.

In waste places throughout the area. Distributed in the Upper Gangetic Plain, Bihar, Gujerat, Bombay, Mysore and Madras; also in Africa.

Grows in rocky and waste places. It is a good fodder grass when young but too small.

3. **Tetrapogon** Desfontaines

Tetrapogon Desf. Fl. Atlant. 2:388 f, 255. 1799; *Chloris* Hook. f. Fl. Brit. Ind. 7:289. 1897 (in part).

A small genus of about 5 species, chiefly Mediterranean. *Tetrapogon tenellus* (Roxb.) Chiov. Ann. I. Bot. Roma. 8:353. 1908; *Chloris tenella* Roxb. Hort. Beng. 82. 1814; Hook. f. Fl. Brit. Ind. 7:291. 1897.

Fairly common in the area in waste places. Distributed in the upper Gangetic Plain, Rajasthan, Sind, Gujerat, Bombay, Madras and further upto Arabia and Abyssina.

Said to be a good fodder grass.

4. **Cynodon** Richard

Cynodon Rich. in Pers. Syn. 1.85. 1805; Hook. Fl. Brit. Ind. 7: 288, 1897.

A small genus of 7 species, distributed in India, South Africa and and Australia.

Cynodon dactylon (Linn.) Pers. Syn. 1.85. 1835; Hook. f. Fl. Brit. Ind.

7:288. 1897
(sans. Durva; Hindi, Doob, Hariyali; the Bermuda grass, the Couch grass, Creeping Dog's-tooth-grass or Creeping Fingergrass)

Grows everywhere abundantly. It is the commonest grass of the area and has a world wide distribution.

"A grass which readily takes possession of abandoned cultivation, paths and depressionsw here water collects, but is only transient as other stronger grasses rapidly oust it. Will survive on moderatlely grazed ground as it stands moderate trampling and the prostrate stems ensure its survival."—Bor (1947). Uses of this grass are manifold. It is one of the best fodder grasses and probably best for horses. It is officinal in Europe. In India it is used medicinally as a diuretic and sedative in cystitis and other diseases. It is also widely used as a packing lawn grass. For soil binding doob is excellent. Dried grass can be used for purposes.

5. **Chloris** Swartz

Chloris Sw. Prodr. Ind. Oce. 25. 1788; Hook f. Fl. Brit. Ind. 7:289.1897.
A genus of about 60 species, in the warmer regions of the world.

Key to the species

A. Rachilla produced beyond the lemma and bearing an awn; gl. II awned ... ... 1. C.DIGITATA

AA. Rachilla produced beyond the lemma and bearing reduced empty gl.; gl. II awnless ... ... 2. C. INFLATA

1. *Chloris digitata* (Roxb) Steud. Syn. Gram. 207. 1854 ; *C. incompleta* Roth Nov. Sp. 60. 1821; Hook. f. Fl. Brit. Ind. 7:290. 1897.

Itmadpur and Tundla in fields during rains, not common. Distributed from the Punjab to Madras; also in Afghanistan, China and Ceylon.

It can thrive on all sorts of soils, except water logged. Relished by the cattle only before flowering. Flowers at the end of rains.
2. *Chlrois inflata* Link, Enum. Pl. 1:105. 1821; *C. barbata* auct. pl. incl. Hook. f. Fl. Brit. Ind. 7:292. 1897.

Common in sandy places throughout the area. Distributed on the plains of India, Burma and Ceylon.

It can stand drought well and grows well on sandy soils. It is considered to be a good fodder grass in certain countries. Flowers at the end of rains and throughout winter.

Tribe 7. AGROSTEAE

A tribe of temperate regions and high mountains of the tropics. Genus only one within the area.

Polypogon Desfontaines

Polypogon Desf. Fl. Atlant. 1:66. 1798; Hook. f. Fl. Brit. Ind. 7:245. 1897.

Specis 10, in warm temparate regions.

Polypogon monspeliensis Desf. Fl. Atlant. 1. 66. 1798; Hook f. Fl. Brit. Ind. 7:245. 1897. (The Beard Grass)

Poiya Ghat, in fields, sporadic. An uncommon grass of the area, appears during winter season especially in wheat fields. Distributed on the upper Gangetic plain, Bihar, Sind and Madras; also in other tropical and temparate regions of the world.

Tribe 8. STIPEAE

Spikelets 1-flowered, lemmas hardened when mature, tightly enveloping the fruit, 3-7-nerved, awn terminal, rarely absent.

Aristida Linn.

Aristida Linn. Sp. pl. 82. 1753; Hook. f. Fl. Brit. Ind. 7:223. 1897.

A large genus of 160 species in the temperate and the sub-tropical regions of the world.

"The most important genus of pioneer and desert or semi-desert grasses. Abundant or dominant over considerable areas in all the drier parts of the tropic and sub-tropics"—Bews (1929).

Key to the Species

A. Awn without a column ... ... 1. A. DEPRESSA
AA. Awn with a column ... ... 2. A. FUNICULATA

1· *Artistida depressa* Retz. Obs. 4:22, 1786; A. *adscensionis* Linn. Sp. pl. 82. 1753; Hook. f. Fl. Brit. Ind. 7:224. 1897 (in part).

Very common in waste places. Distributed in the Punjab. Upper Gangetic Plain and Madras.

A xerophytic grass of arid and semi arid regions, prefering sandy and dry localities. It is eaten by cattle when green and increases the yield of milk and butter.

2. *Artistida funiculata* Trin. and Rupr. in Mem. Acad. Petersb. ser 6.7:159 1849; Hook. f. Fl. Brit. Ind. 7:226. 1897.

Common within the area. Distributed in plains of North India, Cutch Gujerat, Bombay and Eastern district of Madras State; also in Arabia and tropical Africa.

A grass of dry localities. Not of fodder value.

Tribe 9. ZOYSIEAE

Spikelets 1-flowered, falling entire either singly or in clusters of 2-5; glumes equal or the II much smaller or suppressed ; lemmas 'delicately membranous' 1-3 nerved.

Key to the genera.

A.	Spikelets solitary, gl. I & II awned	1. PEROTIS
AA.	Spikelets, clusters of 2-5; gl. I ; & II awnless ...	2. TRAGUS

1. **Perotis** Aiton

Perotis Ait. Hort. Kew ed. 1, 1:85. 1789; Hook. f. Fl. Brit .Ind. 7:98. 1897.

A small genus of about 5 species in the tropics of the Old World and the sub-tropical regions of Australia.

Perotis indica (*Linn.*) O. Kuntze, Rev. Gen. Pl. 787. 1891; *Perotis latifolius* Ait. Hort. Kew. 1:85. 1789; Hook. f. Fl. Brit. Ind. 7:98 1897.

A common grass growing in open waste places and dry fields all over the area. Distributed in India, Ceylon and South Africa.

It is easily distinguished by it sslender purplish squirrel tail-like inflorescence. It prefers sandy places. It is a good fodder and is relished by cattle.

2. **Tragus** Haller

Tragus Hall. Hist. Strip. Helv. 2:203. 1768; Hook. f. Fl. Brit. Ind. 9:97. 1897.

Only two species in tropical and sub-tropical countries of the world..

Tragus biflorus Schult. Mant. 2:205. 1767; *T. racemosus* Scop. Introd. Hist. Nat. 73. 1777; Hook. f. Fl. Brit. Ind. 7:97. 1897.

Common in waste places. Distributed in the plains of India and Ceylon.

A xerophyte, preferring dry localities. It forms a fairly good fodder grass.

Tribe 10 ORYZEAE

A small tribe of acquatic or marsh herbs. Spikelets 1-(rarely 3)-flowered, hermaphrodite or unisexual, falling entire; glumes very minute; lemmas membranous to coriaceous.

Oryza Linn

Oryza Linn. Syst. 1. 1735; Hook f. Fl. Ind. 7: 92. 1897

A small genus of about 17 species growing in the tropics in wet places.

Oryza sativa Linn. Sp. pl. 333. 1753; Hook. f. Fl. Brit. Ind. 7:92. 1897. (Sans. Dhanya; Hindi, Dhan; The Rice plant).

The wild plant occurs in some marshy localities within the area. Our specimen comes from Parkham. It is not cultivated within the area. It grows wild in many places.

Prefers moist and muddy soil. Wild plants of the area are of no use as they are nowhere abundant. Grain is eaten and dispersed by birds. Rice forms the main cereal of a large proportion of the world population.

PANICOIDEAE

It is a distinct subfamily from the Pooideae, having the basic (haploid) chromosome number usually 5. Polyploidy is the rule and the actual number is some multiple of 5.

Tribes 3, within the area.

Key to the tribes of the Panicoideae
(after Bor, 1940)

A. Spikelets all hermaphrodite, with male or barren or hermaphrodit spikelets mixed in the same inflorescence and so arranged that a male or barren spikelet is near a hermaphrodite spikelet, if unisexual then the lemma of the fertile floret indurated.

  B. Spikelets solitary or paired, more or less similar; gls. usually membranous, gl. I usually smaller or sometimes suppressed; lower lemma mostly resembling gl. I in texture; upper lemma papery to very tough and rigid, usually awnless — 1. PANICEAE

  BB. Spikelets often paired, with one sessile and the other pedicelled, those of each pair similar or more often dissimilar, rarely solitary and all alike; gls. as long as the spikelet and enclosing the florets, more or less rigid and firmer than the lemmas which are both hyaline or membranous; upper lemma usually awned ... ... 2. ANDROPOGONEAE

AA. Spikelets all unisexual, with male and female in different inflorescence on the same plant ... ... 3. MAYDEAE (ZEA)

Tribe 1. PANICEAE

This tribe contains about 60 genera, distributed chiefly in the tropical and sub-tropical regions of the world, "where they are abundant but they do not enter very much into the composition of subtropical mesophyte grassland, a type of vegetation, on the other hand is completely dominated by the Andropogoneae"—Bews (1929).

Key to tne genera of Paniceae
(*modified from Bor*, 1940).

A. Spikelets falling singly, not subtended by bristles, or if so, then the bristles persisting after the spikelets have fallen (Setaria).

  B. Spikelets in more or less open panicles, or with the panicles contracted and spike like.

    * Spikelets subtended by one to many bristle-like brnchlets ... ... 11. SETARIA

    ** Spikelets not subtended by bristle like branchlets — 3. PANICUM

  BB Spikelets in one-sided spikes or spike-like racemes; spikes or racemes digitate or scattered, rarely solitary.

    C. Upper lemma, more or less crustaceous or coriaceous, usually with narrow in-rolled margins; palea exposed:—

D. Gl. I and lowest internode of the rachilla forming a swollen callus at the base of the spikelet; upper lemma mucronate or sortly awned ... ... 9. ERIOCHLOA

DD. Gl. I and lowest internode of the rachilla not as in D.

E. Gl. I (when present) turned away from the rachis of the racemes or spikes, the back of the upper lemma facing it i.e. spikelets adaxial.

F. Gls. I developed, although sometimes small:—

G. Gls. I & II acuminate or awned rarely only acute; upper lemma not mucronate:—

* Leaves linear; gls. entire, I awnless 4. ECHINOCHLOA

** Leaves lanceolate; gls. slightly notched gl. I awned ... ... 8. OPLISMENUS

GG. Gls. awnless, if acuminate then with the upper lemma mucronate:—

* Upper lemma acute, not mucronate 6. PASPALIDIUM

** Upper lemma obtuse, mucronate or very short-awned ... ... 7. UROCHLOA

FF. Gl. I usually absent; spikelets plano-convex 5. PASPALUM

EE. Gl. I turned towards the rachis, the back of the upper lemma turned away from it i.e. spikelets abaxial 10. BRACHIARIA

CC. Upper lemma thinly cartilaginous, usually with flat hyaline margins:—

* Spikelets awnless ... ... 1. DIGITARIA

** Spikelets awned ... ... 2. ALLOTEROPSIS

AA. Spikelets surrounded by an involucre of free naked or plumose bristles or of spines or rigid bristles united at the base into a cup.

* Involucre of free, naked or plumose-bristles. 12. PENNISETUM

** Involucre of spines or rigid bristles united at the base into a cup ... ... 13 CENCHRUS

1. **Digitaria** Heister ex Fabricius

Digitaria Heist. ex Fabricius, Enum. Meth. Pl. ed. 1 Helmstedt. 207. 1759; Henr. Monogr. Gen. Digitaria 1950; Bor, in da Webbia 11:301-367. 1955; *Paspalum* Linn. Hook. f. Fl. Brit. Ind. 7:10.1897 (in part).

A large genus of about 325 species more or less cosmopolitan.

Key to the species

(modified from Bor, 1955)

A. Spikelet of each pair heteromorphous, sessile spikelets nearly glabrous in front, the pedicelled coated with long hairs often spreading at maturity.

* Racemes thin and flexible, nodding, usually more than 3; lower lemma of the subsessile spikelet with prominent nerves ... ... 1. D. BIFORMIS

** Racemes rather stout, very stiff, often only 2, divaricate; lower lemma of sessile, spikelets with very prominent nerves, the internerve spaces often slit like ... 2. D. BICORNIS

AA. Spikelets of each pair not heteromorphous, both spikelets of each pair with the same type of indumentum:

* Nerves of the lower lemma smooth, without minute triangular spines on nerves; spikelets without spreading hairs. 3. D. ADSCENDENS

** Nerves of the lower lemma with minute triangular spines, in the upper part; spikelets hairy ... ... 4. D. SANGUINALIS subsp. VULGARIS var. ROTTLERIANA

1. *Digitaria biformis* Willd. Enum. pl. Hort. Berol. 92. 1809. sub-sp. *Willdenowii* Henr. Monogr. Gen. Digitaria 978. 1950.

Parkham (Mathura), R. C. Bharadwaja Oct. 1950 (Herb. Dehra.). Possibly also within our area.

2. *Digitaria bicornis* (Lamk.) R.— & S. ex. Loud. Hort. Britt. 24. n. 1378. 1830; *Panicum heteranthum* Hook. f. Fl. Brit. Ind. 7:16. 1897 (non Nees et Mayen, non Link).

Dr. Bor. (1955) cites a sheet collected by Duthie from Shekohabad (Shikohabad). There is every likelihood of its occurrence within the district of Agra. Distributed in Bengal, Bihar, Upper Gangetic Plain, Bombay and also in Ceylon.

3. *Digitaria adscendens* (H. B. K.) Henr. in Blumea 1:92. 1934.

subsp. *adscendens* Bor, in da Webbia 11 : 351. 1955, var. *criziformis* Bor, ibid.

Common throughout the area during the rainy season.

4. *Digitaria sanguinalis* (Linn.) Scop. Flor. Carn. ed. 2. 1 : 52. 1772.

sub.-sp. *vulgaris* (Schrad.) Henr. var. *rottleriana* Henr. Monogr. Gen. Digtiaria 490. 1950.

Shikohabad, Duthie (Herb. Dehra.). Possibly also within the area. Distributed from Punjab to Madras.

2. **Alloteropsis** C. Presl emend Hitchcock

Alloteropsis C. Presl, Rel. Haenk. 343, T. 47. 1830 emend Hitchcok in Contr. Un. St. Nat. Herb. 12: 210. 1909; *Axonopus* Hook. f. Fl. Brit. Ind. 7: 63. 1897 (non Beauv.); *Coridochloa* Nees in Edin. New Phil. Journ. 15: 381. 1833

Species about 4, distributed in tropical East Africa, South China Australia and in Philippines.

Alloteropsis cimicina (Linn.) Stapf in Fl. Trop. Afr. 9: 487. 1919;
Axonopus cimicinus. Beauv. Ess. Agrost. 12. 1812; Hook. f. Fl. Brit. Ind. 7:64. 1897.

Fields near Kitham, not common. Distributed in the Upper Gangetic Plain, Bihar, Assam, Bengal, Bombay and Madras States; also in Tropical Africa and Madagascar.

Flourishes on all kinds of soil even in waste places; flowers at the end of the rainy season. "Cattle will eat it and it makes up into hay but it is hardly common enough to be of any great importance",—Bor, (1947).

3. **Panicum** Linn.

Panicum Linn. Sp. Pl. 55. 1753; Hook. f. Fl. Brit. Ind. 7 : 26. 1897 (in part).

A large genus of about 400 species, occurring in the tropical, subtropical and warm temperate regions of the World, most of them occur in Africa and America.

Key to the species

A. Gl. I cuspidate-acuminate ... ... 1. P. TRYPHERON
AA. Gl. I not cuspidate-acuminate
  B. Spikelets narrowly lanceolate to lanceolate-oblong, acute ... ... 2. P. PALUDOSUM
  BB. Spikelets oblong, ovate-oblong to elliptic, acute or obtuse.
    C. Annual ... ... 3. P. PSILOPODIUM
    CC. Perennial ... ... 4. P. ANTIDOTALE

1. *Panicum trypheron* Schult. Mant. 2: 244. 1824; Hook. f. Fl. Brit. Ind. 7:47. 1897.

Common in the fields throughout the area. Distributed in the Upper Gangetic Plains, Bihar, Bengal, Assam and the Deccan; also in China and Borneo.

Grows on pasture land and borders of cultivated fields; flowers during the rains. A fair fodder.

This species has been much confused in herbaria but it is easily recognised by its strongly acuminate spreading glumes and lemmas. Upper lemma is obtuse and distinctly shorter than gl. II and lower lemma.

2. *Panicum paludosum* Roxb. Fl. Ind. 307. 1832; P. *proliferum* Hook. f. Fl. Brit. Ind. 7:50. 1897 (*non* Lamck.)

Bund-Baretha, and Parkham, also in Achhnera, not common. Distributed in India, China and Malaya.

Hygrophilous species, growing in marshy places, still waters and river banks. It is said to be perennial. Some specimens are very like *Panicum miliare Lamck.* but they have narrower more acuminate spikelets and narrower fruits. A very good fodder both for buffaloes and cattle.

3. *Pnicum psilopodium* Trin. Gram. Panic. 217. 1826; Hook. f. Fl. Brit. Ind. 7: 46. 1897.

In fields near Agra, occasional. Distributed in India, Burma, Ceylon and Malacca.

It grows on all types of soil except sandy and very wet. Not a good fodder.

4. *Panicum antidotale* Retz. Obs. 4:17.1786; Hook. f. Fl. Brit. Ind. 7: 52. 1897.

Kiraoli, not common. Distributed in the Upper Gangetic Plain, Punjab, Rajasthan, Madras, Bombay, Ceylon and also in Australia.

A grass of hedges and shruby places. Flowers from October to December. Not a good fodder. It has a bitter and saltish taste. Used medicinally for ulcers and in throat affection. Smoke is said to be disinfectant.

4. **Echinochloa** Beauvois

Echinochloa Beauv. Ess. Agrost. 53. 1812; *Panicum* Linn. Sect. *Echinochloa* Hook. f. Brit. Ind. 7:30. 1897.

Species about 20, but variable and difficult to define. Distributed in the warmer regions of the earth.

Key to the species

A. Plants slender, decumbent or shortly creeping at base; gl. I and upper lemma equally acute or cuspidate ... 1. E. COLONA
AA. Plants robust, mostly erect; gl. I and upper lemma cuspidate or produced into an awn ... ... 2. E. CRUS-GALLI

Echinochloa colona (Linn.) Link, Hort. Berol. 2: 209. 1833; *Panicum colonum* Linn. Syst. Veg. ed. 10.870. 1759; Hook. f. Fl. Brit. Ind. 7:32. 1897. (Hindi, Jungli Sawan).

Common in cultivated fields and elsewhere throughout the area. Distributed in the tropical and subtropical regions of the world.

It generally prefers rich soil. Flowers during rains and afterwards. A good fodder grass, grains of which are used as famine food.

2. *Echinochloa crus-galli* (Linn.) Beauv. Ess. Agrost. 161. 1812. *Panicum crus-galli* Linn. Sp. Pl. 56. 1753; Hook. f. Fl. Brit. Ind., 7: 30. 1897.

Agra and Bund-Baretha, not common. Distributed throughout India, ascending on the Himalayas upto 6000 ft. also in Europe, Britain, Africa China, and Japan.

It is a good fodder grass. It prefers moist localities. There are several specimens intermediate between *E. crus-galli* and *E. colona*. Watts' *Eleusine crus-galli* is an obvious mistake for *Echinochloa crus-galli*.

5. **Paspalum** Linn.

Paspalum Linn. Syst. ed. 10.855. 1759; Hook. f. Fl. Brit. Ind. 7: 10. 1897 (in part).

A large genus, distributed mainly in tropical and temperate America where they form extensive grass lands like Campos and Pampos.

Paspalum distichum Linn. Syst. Nat. ed. 10. 2. 855. 1759; Hook. f. Fl. Brit. Ind. 7: 12. 1897.

Parkham and Achhnera, near water. It is a grass of wet places and moist soil. Distributed in the warm countries of the world.

"This grass is a useful soil-binder and a good fodder grass'—Bor (1941).

6. **Paspalidium** Stapf

Paspalidium Stapf in Fl. Trop. Afr. 9:15. 1917. *Panicum* Linn. Sp. 55. 1753; Hook. f. Fl. Brit. Ind. 7:28. 1897 (in part).

Species 12 in the warm regions of the world.

Key to the species

A.	Spikes shorter than internodes	1. P. FLAVIDUM
AA.	Spikes longer than internodes	2. P. GEMINATUM

1. *Paspalidium flavidum* (Retz. A.) Camus in Lecomote, Fl. Gen. de I' Indo-China 7:419. 1922; *Panicum flavidum* Retz. Obs. 4:15. 1786; Hook. f. Fl. Brit. Ind. 7:28. 1897.

Common in fields throughout the area. Distributed all over the plains of India, ascending on the Himalayas upto 6000 ft. Ceylon, tropical Africa and Asia.

It is a good fodder grass that prefers moist places. Grain is used as human food in famine. Some browsed specimens are only a few centimeters high with sometimes a single spike of two spikelets.

2. *Paspalidium geminatum* Stapf in Fl. Trop. Afr. 9:583. 1920; *Panicum paspaloides* Pers. Syn. 1: 81. 1805; Hook. f. Fl. Brit. Ind. 7:30. 1897.

Bund-Baretha (Bharatpur), generally found in moist places, not common; likely to occur within the area in similar localities. Distributed almost throughout the tropics. A semi-aquatic grass.

7. **Urochloa** Beauvois

Urochloa Beauv. Ess. Agrost. 52. 1812; *Panicum* Linn. Sp. Pl. 55. 1753; Hook. f. Fl. Brit. Ind. 7:26.1897 (in part).

Species about 18, in the warm regions of the Old World. This genus is closely allied to *Brachiaria* Griseb., from which it differs in the orientation of the spikelet, which is not readily noticed and in upper lemma being abruptly mucronate or aristulate.

Urochloa helopus (Trin.) Stapf in Fl. Trop. Afr. 9:595. 1920:*Panicum javanicum* Hook. f. Fl. Brit. Ind. 7:35. 1897 (non Poir).

Agra, in fields, not common. Distributed in the plains of India, Ceylon, tropical and South Africa and Mauritius.

Generally grows on the borders of cultivated fields and on pasture grounds. It forms a good fodder.

8. **Oplismenus** Beauvois

Oplismenus Beauv. Fl. Oware et Benin 2: 14. 1807-18; Hook. f. Fl. Brit. Ind. 7:65. 1897.

Species 15, in all the warmer regions of the World.

Opilismenus burmanii Beauv. Ess. Agrost. 54. 1812; Hook. f. Fl. Brit. Ind. 7:68. 1897.

In moist and shady places, throughout the area, but not very common. Distributed throughout the tropics. Flourishes well under a deep shade. It is not liked by cattle.

9. **Eriochloa** Humboldt, Bonpland & Kunth

Eriochloa H. B. & K. Nov. Gen. et. Sp. i, 94t, 30, 31. 1815; Hook. f. Fl. Brit. Ind. 7: 20. 1897.

A genus of about 25 species, distributed in the warmer regions of the World.

Eriochloa procera Hubb. in Kew Bull. 26. 1930; *E. polystachya* H.B. & K. Nov. Gen. et. Sp. 1:95. 1815; Hook. f. Fl. Brit. Ind. 7:20. 1897.

In marshy places throughout the area. Distributed in the Indo-Malayan region and Africa.

Prefers moist localities where sometimes it forms gregarious patches. It is much liked by cattle.

10. **Brachiaria** Grisebach

Brachiaria Griseb. in Lede. Fl. Ross. 4: 469. 1853; *Panicum* Linn. sect. *Brachiaria* and part of sect. *Paspaloideae* of Hook. f. Fl. Brit. Ind. 7: 26. 1897.

Species about 50 in the warmer regions of the world, mostly Africa.

Key to the species

A. Spikelets 1.8-2.5 mm. long
  * Spikelet softly pubescent ... ... 1. B. ERUCIFORMIS
  ** Spikelets glabrous ... ... 2. B. REPTANS
AA. Spikelets 2.5-4 mm. long
  C. Spikelets turgid, broadly elliptic or broadly ovate-elliptic, apiculate ... ... 3. B. RAMOSA
  CC. Spikelets not turgid
    * Spikelets mostly crowded ... ... 4. B. DISTACHYA
    ** Spikelets distant ... ... 5. B. KURZII

1. *Brachiaria eruciformis* (Sib. & Sm.) Griseb. in Ledeb. Fl. Ross. 4: 469. 1833; *Panicum isachne* Roth. Nov. Pl. Sp. 54. 1821; Hook. f. Fl. Brit. Ind. 7: 28. 1897.

Common throughout the area. Distributed in the plains of India; also in Ceylon, Italy and North Africa.

It prefers slightly moist localities and forms a fairly good fodder.

2. *Brachiaria reptans* (Linn.) Gard. et Hubb. in Hook. Ic. Pl. sub. tab. 3363; 1938; *Panicum prostratum* Lamk. III. 1:177 1791; Hook. f. Fl. Brit. Ind. 7:33. 1897.

Fairly common throughout the area. Distributed in the plains of India, Ceylon and subtropical America; also in tropical Arabia and Mascarenes. Good as fodder. This species has much resemblance with *Brachiaria distachya* Stapf, but glume I is not more than 1/4 the length of the spikelet instead of nearly half.

3. *Brachiaria ramosa* (Linn.) Stapf in Fl. Trop. Afr. 9: 452. 1919; *Panicum ramosum* Linn. Mant. 29. 1767; Hook. f. Fl. Brit. Ind. 7: 36. 1897 (in part).

Bichpuri and Sikandra, common. Distributed throughout the plains of India; also in Afghanisthan, tropical Africa and Indo-China.

Thrives well in cutivated fields. A good fodder grass.

4. *Brachiaria distachya* (Linn.) Stapf in Fl. Trop. Afr. 9: 565. 1919; *Panicum distachyum* Linn. Mant. 1: 138. 1767; Hook. f. Fl. Brit. Ind. 7:37. 1897.

In fields near Sikandra, common; also in Etawah (Herb. Dehra). Distributed throughout the plains of India; also in China, Australia and Malaya.

Prefers sandy and loamy soil. Forms a good fodder grass. It is cultivated in Australia for fodder.

5. *Brachiaria kurzii* (Hook. f.) A. Camus in Lecomte, Fl. Gen. de.l' Indo-Chine 7: 438. 1922. *Panicum kurzii* Hook. f. Fl. Brit. Ind. 7: 38. 1897.

Fairly common in fields throughout the area. Distributed from India to Siam. A fairly good fodder grass.

This species seems to be scarcely more than a form of *B. ramosa* Stapf. with less turgid spikelets, always glabrous on longer pedicels.

11. **Setaria** Beauvois

Setaria Beauv. Fl. Oware et Benin 2: 80. 1807; Hook. f. Fl. Brit. Ind. 7: 78. 1897.

Species 100 in the tropics and subtropics.

Key to the species

A. Bristles retrosely barbed ... ... 1. S. VERTICILLATA
AA. Bristles antrosely barbed:—
    * Inflorescence a narrow panicle, lobed, specially in the lower part, tapering upwards ... ... 2. S. INTERMEDIA
    ** Inflorescence a cylindric false-spike ... ... 3. S. LUTESCENS

1. *Setaria verticillata* Beauv. Ess. Agrost. 51. 1812; Hook. f. Fl. Brit. Ind. 7: 80. 1897.

Common near hedges and walls throughout the area. Distributed throughout India and Ceylon. It is readily distinguished from other species by its sticking to ones clothing.

Grows in shady places specially on rich soil. It is eaten by the cattle before flowering. Grain is eaten by poor classes.

2. *Setaria intermedia* (Roth.) R. & S. Syst. 2 : 489. 1817; Hook. f. Fl. Brit. Ind. 7 : 79. 1897.

Common throughout the area in shady places. Distributed throughout the plains and low hills of India; also in Ceylon.

It is a weed of cultivation during rains. "Cattle are very fond of this grass as the leaves are flacid and tender"—Achariayar & Mudaliar (1921).

Stewart (1945) calls this grass as *S. tomentosa* (Roxb.) Kunth.

3. *Setaria lutescens* (Weigel) Hubb. Rhodora 18: 232. 1916; *Panicum lutescens* Weigel Obs. 20. 1772; *Setaria glauca* of Hook. f. Fl. Brit. Ind. 7: 78. 1897.

Common throughout the area in cultivated fields and gardens. Distributed in all warm and temperate regions of the world.

It prefers rich and cultivated soil, where sometimes it becomes gregarious. It is considered to be a good fodder grass. "The seeds have been used as a food during famine time."—Blatter and McCann (1935)

12. **Pennisetum** Richard

Pennisetum Rich. in Pers. Syn. 1:72. 1805; Hook. f. Fl. Brit. Ind. 7: 82. 1897 (in part).

A large genus of about 130 species, in tropics and warm regions of the globe. Several sepecies are cultivated.

Pennisetum typhoides Stapf & Hubb. in Kew Bull. 271. 1933; *P. typhoideum* Rich in Pers. Syn. 1 : 72. 1805 (in part) Hook. f. Fl. Brit. Ind. 7: 82. 1897. (Hindi, Bajra; The Pearl millet).

Cultivated throughout the area. Distributed in the hotter parts of India, cultivated or an escape; also in South Europe and Africa.

Cultivated for fodder and the grain is eaten.

Stewart (1945) calls this grass as *P. glaucum* (Linn.) R. Br.

13. **Cenchrus** Linn.

Cenchrus Linn. Sp. pl. 1049,1753, Hook. f. Fl. Brit. Ind. 7: 89. 1897. (1897) Species 25, mostly tropical and temperate.

"Spikelets are surrounded by an involucre of sterile spikelets which in some species become hard and prickly, surrounding the fruit and acting as a means of distribution by animals" Willis (1951).

Key to the species

A. Involucre of sterile spikelets not spinose ... ... 1. C. CILIARIS
AA. Involucre of sterile spikelets spinose.
  * Base of the involucre rounded, bristles all erect, eciliate 2. C. SETIGERUS
  ** Base of the involucre turbinate, bristles stout the outer spreading or recurved, ciliate ... ... 3. C. BARBATUS

1. *Cenchrus ciliaris* Linn. Mant. 2: 302. 1771; *Pennisetum cenchroides* Rich. in Pers. Syn. 1 : 72. 1805; Hook. f. Fl. Brit. Ind. 7 : 88. 1897.

Common in fields and waste lands throughout the area. Distributed in India, Africa, Sicily and Canaries.

Grows on all kinds of soil and thrives even on dry soil and when once established is not easily killed by droughts. Flowers from June to January. It forms an excellent fodder in young stage.

2. *Cenchrus setigerus* Vahl, Enum. 2: 395. 1806; *C. biflorus* Roxb. Hort. Beng. 81, 1814 (name only); Hook. f. Fl. Brit. Ind. 7: 89. 1897.

Fairly common in fields and waste places, throughout the area. Distributed in the Indo-Gangetic Plain, Bombay, Gujrat, Madras; also in Arabia, Nubia and Ethopia. It is a psammohilous grass. Flowers during rains. It is said to be a nutritious grass.

3. *Cenchrus barbatus* Schum. in Schum. & Thom. Beskar. Gunin. Pl. 43. 1827; *C. catharticus* Del. Cat. Hort. Monsp. 1838 ex Linnaea 13: Litt. 103. 1839. Hook. f. Fl. Bri. Ind. 7 : 90. 1897.

Common in lawns, waste places and pastures throughout the area. Distributed in the Upper Gangetic Plain, Punjab, Madras and Bombay States; also in tropical Africa and Arabia.

Grows mostly in sandy or arid soil. Matures burs readily get attached to passing animals, the seeds thus being widely distributed. Liked by the cattle only in young stage.

Tribe 2. **Andropogoneae**

Genera 71, containing "the dominant grasses of tropical and subtropical savannas, with extensions into the temperate regions"—Bews (1929). Genera 18 within the area. Chromosome numbers 5, 9, (10) 12.

Key to the genera

A. Internodes of the rachis and pedicels slender, filiform; rarely thickend upwards; or if thickened upwards spikelets 1-flowered and awned.

B. Spikelets all alike or very similar in shape and sex, 1-2-flowered.

% Spikelets all pedicelled; rachis of racemes continuous and tough ... ... 1. IMPERATA

%% Spikelets, one sessile and the other pedicelled

* Upper lemma obtuse or absent ... ... 2. SACCHARUM

** Upper lemma mucronate or awned ... 3. ERIANTHUS

BB Spikelets of each pair different in sex and usually also in shape and size; the pedicelled spikelets male or barren

C Panicles subtended by spathes; racemes 2 or 1, rarely more on a common peduncle sheathed by a spatheole

D. Racemes reduced to 1 or a few nodes with or without a surrounding involucre of modified male or empty spikelets:—

* Involucre of spikelets persistent, the rest jointed on the rachis and falling separately ... 11. THEMEDA

** Involucre of spikelets jointed on the peduncle and falling with the rest. ... ... 12. ISEILEMA

DD. Racemes many-noded, not reduced nor involucred

E Racemes solitary in each spatheola ... 8. EREMOPOGON

EE. Racemes twin in each spatheole

* Aromatic; lowest pair of spikelets usually homogamous ... ... 10. CYMBOPOGON

** Non-aromatic; lowest pair of spikelets heterogamous ... ... 9. ANDROPOGON

CC. Panicles naked i. e. not subtended by spatheoles

F. Upper lemma reduced to the hyaline stipiform base of awn; joints and pedicels filiform with a transluscent longitudinal depression. ... 6. BOTHRIOCHLOA

FF. Upper lemma not reduced, 2-fid awned from the sinus, joints and pedicels solid.

G. Racemes usually verticillate or in panicle along the axis:

* Gl. I more or less flattened on back; spikelets dorsally compressed ... 4. SORGHUM

** Gl. I rounded on back and muriculate or tuberculate; spikelets laterally compressed; roots aromatic ... ... 5. VETIVERIA

GG. Racemes solitary, scattered or digitate:—

* Racemes solitary ... ... 13. HETEROPOGON

** Racemes digitate or scattered 7. DICHANTHIUM

AA. Internodes of the rhachis usually stout and thickened upwards or throughout or flattened; pedicels often similar to the internodes; spikelets 1-2-flowered; upper lemma awned or awnless:—

H. Upper lemma usually awned (awnless in *Apluda mutica* Linn.)

I. Racemes of many internodes and pairs of spikelets
* Racemes paired, digitate or sub-digitate — 14. Ischaemum
** Racemes solitary ... ... — 15. Sehima
II. Racemes reduced to 3 spikelets, partially enclosed by spathes ... ... — 16. Apluda
HH Upper lemma awnless:—
* Spikelets all alike, also in sex; racemes tough or tardily disarticulating, much compressed, joints and pedicels fused ... — 17. Hemarthria
** Spikelets of each pair more or less dissimilar at least as to sex, the pedicelled male or neuter — 18. Elyonurus

1. **Imperata** Cyrillo.

Imperata Cyrill. Pl. Rar. Neap. 2 : 26. 1792; Hook. f. Fl. Brit. Ind. 7: 106. 1897.

A small genus of only 9 species, occurring in the warmer regions of the world.

Imperata Cylindrica (Linn.) Beauv. Ess. Agrost. 8, 165. pl. 5, f. 1. 1812.

I. arundinacea Cyrill. Pl. Rar. Neap. 2 : 26. 1792; Hook. f. Fl. Brit. Ind. 7 : 106. 1897. (Sans. Darbh; Hindi, Dabh).

Bichpuri Agricultural Farm, gregarious, possibly also in other places. Distributed throughout the hotter parts of India, ascending on the Himalayas upto 8000 ft; also in Ceylon, Java, Japan, China and Australia.

This grass is eaten by cattle when young. It is also of use as a raw material for paper making.

A very variable plant and several varieties have been recorded by earlier workers according to the size of the plant and hairiness of the nodes, but all such forms are only ecoforms of the same species. For ecology see Hole (1911).

2. **Saccharum** Linn.

Saccharum Linn. Gen. Pl. 18. 1737; Hook. f. Fl. Brit. Ind. 7 : 118. 1897.

A genus of 10 species chiefly in Asia.

Key to the species

A. Culms densely leafy above, glabrous below the panicle; cultivated ... ... — 1. S. officinarum
AA. Culms not leafy above, silky below the panicle; wild ... — 2. S. spontaneum

1. *Saccharum officinarum* Linn. Sp. Pl. 54. 1753; Hook. f. Fl. Brit. Ind. 7; 118. 1897. (Sans. Ikshu; Hindi, Ganna, Ikh, Ukh, Ponda, Ganda; The Sugar-Cane plant).

Cultivated in canal-irrigated areas within the district; and in several parts of India.

2. *Saccharum spontaneum* Linn. Mant. 2 : 183. 1771; Hook f. Fl. Brit. Ind. 6 : 118.1897; (Sans. Kash; Hindi, Kans).

Very common along the river banks and in damp depressions, also in dry localities along the railway tracts. Distributed throughout India on plains, tropical Africa and Syria to China and Australia.

A variable grass either stoloniferous or tufted. An excellent grass for thatching. Leaf sheath is used for making strong strings. It is an excellent sand binder. Relished by buffaloes only. It is a troublesome weed in cultivated fields.

3. **Erianthus** Michaux

Erianthus Michx. Fl. Bor. Amer. 1. 1803; Hook. f. Fl. Brit. Ind. 7: 121. 1897;

A genus of about 20 species, in the warmer regions of the world.

Like *Saccharum*, members of this genus are perennial, tall, coarse grsses with silky panicle.

Key to the species

A. Awns of the upper lemma distinctly exserted from the spikelet 1. E. RAVENNAE
AA. Awns of the upper lemma scarcely exserted 2. E. BENGALENSE.

1. *Erianthus ravennae* (Linn.) Beauv. Ess. Agrost. 14. 1812; Hook. f. Fl. Brit. Ind. 7 : 121. 1897.

Common in Kitham, Parkham and other places where water remains for a long time, also along the banks of the Jumna and the Chambal. Distributed in Western Himalaya, Punjab the Upper Gangetic Plain, Sind, Bombay extending westward upto the Mediterranean.

Culms are used for making screens, for thatching and for *kutcha* walls. Young leaves are eaten by buffaloes. It is cultivated as ornamental. For ecology see Hole (1911).

2. *Erianthus bengalense* (Retz.) Hubbard & Vaunghan, Grasses of Mauritius. 97. 1940; *Saccharum munja* Roxb. Fl. Ind. 1: 250. 1820; *S. arundinaceeum* of Hook. f. Fl. Brit. Ind. 7 : 119. 1897. (Hindi: Munja, Sarkanda).

Grows mixed with *Saccharum spontaneum* Linn. in similar localities through out the area. Distributed in the Upper Gangetic Plain, Bombay, Sind and Gujrat.

"Grows best on alluvial sandy depositions in the neighbourhood of streams where soil is not water-logged. It can however grow on the driest of soils"-Bor (1947). The fibre (Munj) obtained from the leafsheath of the flowering stem is used for ropes and matting. The thin end of the flowering stem (Sirki) is used for cart-covers, winnowing trays, etc., the thick end (Bind or Sentha) is used in place of bamboo for repairing, screens, chairs etc. Leaves are eaten by cattle when young but are chiefly used for thatching. It is an excellent sand binder.

4. **Sorghum** Persoon

Sarghum Pers. Syn. 1 : 101. 1805. *Andropogon. subge. Sorghum* Hook. f. Fl. Brit. Ind. 7 : 181. 1897.

An important genus of about 30 species, several of which and their varieties are cultivated all over the world as cereals and for fodder.

Key to the species

A. Spontaneous grass; spikelets deciduous ... ... 1. S. HALEPENSE.
AA. Cultivated grass; spikelets persistent ... ... 2. S. VULGARE.

1. *Sorghum halepense* (Linn.) Pers. Syn. 1: 10. 1805; *Andropogon halepensis* Brot. Fl. Lus. 1 : 89. 1804; Hook. f. Fl. Brit. Ind. 7 : 182. 1897. (Hindi: Barru; The Johnson grass).

Common throughout the area in cultivated and uncultivated grounds. Distributed throughout India Burma and Ceylon; also in other warmer countries.

A good fodder. The grain is sometimes eaten by poor classes.

2. *Sorghum vulgare* Pers. Syn. 1 : 101. 1805. *Andropogon sorghum* Brot. Fl. Lus. 1 : 88. 1804, Hook. f. Fl. Brit. Ind. 7 : 183. 1897. (Hindi: Juar, Chari; The Great millet).

Cultivated throughout the area. Distributed in the warmer regions of the world.

Cultivated for grain and fodder. Culms are used for making temporary walls and screens.

5. **Vetiveria** Bory.

Vetiveria Bory in Lem. Bull. Soc. Philom. 43. 1822; Thouars ex Virey in Journ. Pharm. ser. 113:449. 1827; *Andropogon* subge. *Vetiveria* Hook. f. Fl. Brit. Ind. 7:186. 1897.

A small genus of 7 species, occurring mainly in the tropics of the Old World.

Vetiveria zizanioides (Linn) Nash in Small, Fl. S. E. U. S. 67. 1903
Andropogon squarrosus Hook. f. Fl. Brit. Ind. 7:186. 1897 (non Linn. f) (Sans. Ushir; Hindi, Khas).

Near marshes and ponds. Distributed throughout India and tropical Asia; also in tropical Africa, introduced elsewhere.

Prefers heavy soil, where it is gregarious. *Vetiver oil* is distilled from the roots and used in perfumary and medicine. Powdered roots are mixed with *Abir* by Hindus at the Holi festival. Inflorescence stalk is used for fancy baskets, brooms and cheap toys. Cooling *tatties* and screens are prepared from roots, called *Khas* in India.

6. **Bothriochloa** O. Kuntze.

Bothriochloa Kuntze Rev. Gen. 762. 1891; *Andropogon* subge. *Amphilophis* Hook. f. Fl. Brit. Ind. 7:171. 1897 (in part)

A genus of about 25 species, mostly perennial, occurring in the tropics of a Asia and Africa.

Key to the species

A.	Inflorescence axis longer than the lowest raceme	...	1. B. INTERMEDIA.
AA.	Inflorescence axis shorter than the 'o vest raceme	...	2. B. PERTUSA

1. *Bothriochloa intermedia* (R. Br.) A. Camus in Ann. Soc. Linn. Lyon II. 76 :.164 1930-1931; *Andropogon intermedius* R. Br. Prodr. 202. 1811; Hook. f. Fl. Brit. Ind. 7 : 175. 1897.

Common in damp places; Distributed throughout India, Ceylon, Caucasus, China, Malaya and tropical Africa.

"Densely tufted, growing in damp places in clumps and also in rocks, in streams on heavy and poorly aerated soil; flowers in the cold weather"-Bor 1947 . Eaten only in green stage.

2. *Bothriochloa pertusa* (Linn.) A. Camus in Ann. Soc. Linn. Lyon II. 76·164. 1930-31; *Andropogon pertusus* Willd. Sp. pl. 4:922. 1806; Hook. f. Fl. Brit. Ind. 7:173. 1897.

Very common in lawns and cultivated fields. Distributed in the Upper Gangetic Plain, Punjub, Bihar, Orrisa Madhya Pradesh, Gujerat, Madras and Bombay; also in tropical Asia, Africa and Australia.

Perennial grass which can withstand cutting and grazing. Flowers from October to February. It is a good fodder grass both for grazing and stacking. Can be used also as a lawn grass.

7. **Dichanthium** Willemet.

Dichanthium Willem. in Ust. Neu. Am. Bot. 12.:11. 1796; *Andropogon* subge. *Dichanthium* Hook. f. Fl. Brit. Ind. 7:195. 1897.

Species about 10, occurring in tropics and warm temperate regions of the world.

1. *Dichanthium annnlatum* (Forsk. Stapf in Fl. Trop. Afr. 9:178. 1917; *Andropogon annhlatus* Forsk. Fl. Aeg. Arab. 173. 1775; Hook. f. Fl. Brit. Ind. 7:196.1897.

Common in fields throughout the area. Distributed throughout the hills and plains of India from Kashmir to Bengal and southwards; also in Africa, China, Australia and Pacific Islands.

Grows in cultivated fields and gardens and likes sheltered situations. An excellent fodder grass. "The best time for cutting this grass is the flowering stage when the nutreints reach a maximum"-Bor (1947).

8. **Eremopogon** Stapf.

Eremopogon Stapf in Fl. Trop. Afr. 9. 1913; *Andropogon* Hook. f. Fl. Brit. Ind. 7:168. 1897 (in part).

Species only 5' in tropics and warm temperate regions of the Old World.

Erempogon strictus (Roxb.,A. Camus in Ann. Soc. Linn. Lyon, n.s. LXVIII. 208.1922; *Andropgon foveolatus* Del. Fl. D'Egypt. t8, fig. 2. 160.1812; Hook f. Fl. Brit. Ind. 7:168. 1897.

Karaoli and Bund-Baretha. Distirbuted in Sind, Cutch, Gujerat, Madras, Bombay and other drier parts of India; also in tropical Africa, Egypt and Arabia.

A grass of drier area and forms a good fodder but is not abundant.

9. **Andropogon Linn.**

Andropogon Linn. Sp. Pl. 1045. 1753; Hook. f. Fl. Brit. Ind. 7:170. 1897 (in part).

Species 100, mostly found in the tropics of the world.

Andropogon pumilus Roxb. Fl. Ind. 1:273. 1832; Hook. f. Fl. Brit. Ind. 7:170. 1897.

Etawah, Duthie (Herb. Dehra). Possibly also within this area. Distributed throughout India.

Grows on moist soil but can do well on dry and semi-dry conditions. Under cultivation, it grows taller and produces more foliage; flowers at the end of the rainy season. It is considered to be a good fodder grass and is readily eaten by cattle when green or dry.

10. **Cymbopogon** Sprengel.

Cymbopogon Spreng. Pug. 2:14. 1815; *Andropogon* subge. *Cymbopogon* Hook. f. Fl. Brit. Ind. 7:202. 1897.

Species 40, in temp. and subtrop. regions of the world.

This genus contains several aromatic grasses of commercial importance.

Key to the species

A.	leaf-blades folded, narrowly linear, upto 30 cm. long, .3 cm. wide (when flat) apex filiform, glaucecesnt, scaberulous on the back and on the margins, laxly hairy below; sheaths of the basal leaves 5-10 cm. long, white, woolly hairy below, glabrescent above, persistent; ligules scarious, rotundate-truncate, 1-5 mm. long	1. C. PARKERI.
AA.	Leaf-blades semiterete, filiform, wiry flexuous, very firm and often circinate upwards, rounded on back, channelled on the face, or those of the culms some what flatter and shorter, upto more than 23 cm. long 1 mm. in diameter, glabrous, finely scaberulous on the nerves below; ligules membranous to scarious, oblong, truncate, ciliate, upto 3.3 mm. long; sheaths very fine, smooth, glabrous	2. C. SCHOENANTHUS.

1. *Cymbopogon parkeri* Stapf in Kew Bull. 10. 1929.

Jumna ravines near Agra, Duthie (Herb. Dehra); Etawah, Parker. (Herb. Dehra.). Distributed in the Upper Gangetic Plain.

Its value as a fodder is uncertain. "May be used for covering dry sunny slopes "—Bor (1947).

2. *Cymbopogon schoenanthus* Spreng. Pug. 2:15. 1815 (non Schult); *Andropogon jwarancusa* subsp. *laniger* (Desf.) Hook. f. Fl. Brit. Ind. 7:203. 1897.

Kailash and Kiraoli in sandy places, not common. Distributed in Punjab, Sind, Baluchistan and Afghanistan; also in North Africa, Arabia and Persia.

"This is a characteristic desert plant requiring very little water"—Blatter & McCann (1935). Not a very good fodder grass. Eaten by cattle only in young stage.

11. **Themeda** Forskal.

Themeda Forsk. Fl. Aegypt. Arab. 178. 1775; *Anthistiria* Linn. Nov. Gram. Gen. 35. 1779; Hook. f. Fl. Brit. Ind. 7:210. 1897.

A genus of about 15 species, confined to the tropics of the Old World.

Themeda quadrivalvis. O. Ktze. Rev. Gen. Pl. 2:94. 1891; *Anthistiria ciliata* Linn. f. Suppl. 113. 1781; Hook. f. Fl. Brit. Ind. 7:213. 1897.

Kenoyer (1922) reports it from Gwalior; likely to occur in this area. A native of India, introduced elsewhere.

It can tolerate dry conditions; flowers at the end of rains. Supposed to be a good fodder grass.

Dr. Henrard (1941) calls this grass as T. *arguens* (Linn.) Hack.

12. **Iseilema** Anderson.

Iseilema Anders. in Nova. Acta. Soc. Sci. Upsal. ser. III. 2:250. 1865; Hook f. Fl. Brit. Ind. 7:217. 1897.

A small genus of 15 species, found in the Indo-Malayan regions.

Key to the species

A. Spathe broad, without tubercles on the keel and margins 1. I. LAXUM.
AA. Spathe comparatively narrow, with tubercles on the keel and margins ... ... 2. I. PROSTRATUM.

1. *Iseilema laxum* Hack. Monogr. Androp. 682. 1889; Hook. f. Fl. Brit. Ind. 7:218. 1897.

"Upper Gangetic Plain" Hook. f., possibly also within the area. Distributed in the Upper Gangetic Plain, Orissa, Bihar, Bombay and Mysore States.

"Common on low-lying land where the soil is good" Duthie. "The spikelets in this and the other species are carried away by the wind in a body"-Blatter & McCann (1935). An excellent fodder grass.

2. *Iseilema prostratum* (Linn.) Anders. in Nova. Acta. Soc. Sci. Upsal. III. 2:251. 1858; I. *wightii* Anders. ibid; Hook. f. Fl. Brit. Ind. 7:218. 1897

Kiraoli, not common, possibly in other localities also.

Distributed throughout India. "An excellent fodder"-Fischer (1934).

13. **Heteropogon** Persoon.

Heteropogon Pers. Syn. pl. 2:533.1807; *Andropogon* subge. *Heteropogon* Hook. f. Fl. Brit. Ind. 7:199. 1897.

This genus contains only 6 species, distributed in the tropics and subtropical regions of the World.

Heteropogon contortus (Linn.) Beauv. ex. R. &. S. Syst. Veg. 2:836. 1817; *Andropogon contortus* Linn. Sp. Pl. 1045. 1753; Hook. f. Fl. Brit. Ind. 7:199. 1897 (The Spear grass).

Common throughout the area in dry sandy localities, gregarious near Kitham. Distributed in India and other tropical and subtropical regions of the world; also in the Mediterranean region.

It grows on a variety of soils and often becomes gregarious on poor soil. "Forms an excellent hay and is eaten greedily by cattle before the inflorescence forms. When the fruit is mature cattle avoid it, but they will eat it in default of anything else. The awned fruits, however, cause severe sores in the gums and mouths of cattle and it is best not to allow cattle near it at this stage. In areas of plentiful rainfall it is possible to take several cuttings of this grass during the rains and this is possibly the best way to manage it"-Bor (1947).

14. **Ischaemum** Linn.

Ischaemum Linn. Sp. Pl. 1049. 1753; Hook. f. Fl. Brit. Ind. 7:126.1897 (in part).

Species about 53, a majority of them occur in the tropics of the Old World, a few in America and about 30 in India.

Ischaemum hirtum Hack. Monogr. Androp. 228. 1889; Hook. f. Fl. Brit. Ind. 7:135. 1897.

Kenoyer (1922) reports this grass from Gwalior, but the authors have not collected it from this area nor they have seen any sheet in the Herbarium of Dehra Dun, from the Upper Gangetic Plain. Distributed in Bengal, Bihar Chota Nagpur, Khasi Hills and Madhya Bharat.

15. **Sehima** Forskal.

Sehima Forsk. Fl. Aegypt. Arab. 178. 1775; *Ischaemum.* sect. *Sehima* Hook f. Fl. Brit. Ind. 7:136. 1897 (in part)

A small genus of 7 species, found mainly in the tropics of the Old World.

Key to the species

A. Joints and pedicels ciliate on both edges; spikelets 6-7 mm. long; gl. I of sessile spikelets 6-nerved ... ... 1. S. NERVOSUM
AA. Joints and pedicels ciliate on one edge only; spikelets 9 mm. long; gl. I of sessile spikelet 2-nerved ... ... 2. S. sulcatum.

These two species are very similar in appearance.

1. *Sehima nervosum* (Rottl.) Stap in Fl. Trop. Afr. 9:36. 1917 ; *Ischaemum laxum* R. Br. Prodr. 205. 1810; Hook. f. Fl. Brit. Ind. 7:136. 1897. (Hindi: Seran.)

Gwalior, Masters (Herb. Dehra); Etawah, Benskin (Herb. Dehra). Our specimen comes from Kiraoli Tehsil. Distributed in India, Ceylon, Africa, Indo-China and tropical Australia.

It is an excellent fodder grass. Flowers at the beginning of winter.

2. *Sehima sulcatum* (Hack) *A camus* in Bull. Mus. Hist. Nat. 5. 373. 1921 ; *Ischaemum sulcatum* Hack. Monogr. Androp. 248. 1889; Hook f. Fl. Brit. Ind. 7:137. 1897. (Hindi: Ponia).

Gwalior, Masters (Herb. Dehra) possibly within our area also. Distributed in the Upper Gangetic Plain, Madhya Pradesh, Bombay and Madras states.

"It requires good drainage and flourishes in areas of low rainfall and is found on medium black soil (M.P. and Bombay).

"This grass is valued as a green fodder and moreover makes up into an excellent hay"—Bor (1947).

16. **Apluda** Linn.

Apluda Linn. Sp. Pl. 82. 1753; Hook. f. Fl. Brit. Ind. 7:150. 1897.

A genus of only one or two species, chiefly occurring in Indo-Malayan region and Madagascar.

Apluda aristata Linn. Cent. 2:7. 1756; *Apluda varia* Hack. subsp. *aristata* Hack. Monogr. Androp. 196. 1889; Hook. f. Fl. Brit. Ind. 7:150. 1897.

Agra, P. Maheshwari (Herb. Dehra); Etawah, Duthie (Herb. Dehra). Throughout the area during monsoons in hedges and bushes. Distributed throughout the tropics of the Old World.

It can grow on a variety of soils. Plants in hedges and bushes assume a scandent habit. A fair fodder, eaten by buffaloes only when young.

Apluda mutica Linn. Sp. Pl. 82. 1753; *Apluda varia* Hack. sub. sp. *mutica* Hack. Mongr. Androp. 196. 1889; Hook f. Fl. Brit. Ind. 7:150. 1897.

This species differs from A. aristata Linn. in that the upper lemma of the sessile spikelet is awnless and the gl. II. glabrous and acute.

17. **Hemarthria** R. Brown.

Hemarthria R. Br. Prodr. Fl. Nov. Holl. 207. 1810; *Rottboelia* sect. *Hemarthria* Hook. f. Fl. Brit. Ind. 7:152. 1897.

A small genus of only 8 species, occurring throughout the warmer regions of the Old World.

Hemarthria compressa (Linn. f.) R. Br. Prodr. 207. 1810; *Rottboelia compressa* Linn. f. Suppl. 114. 1781; Hook. f. Fl. Brit. Ind. 7:153. 1897. (Hindi: Gandel).

Shikohabad, Duthie (Herb. Dehra.). Our specimen comes from Bund Baretha.

A hygrophilous species, growing in rice fields and other moist situations. It is liked by cattle.

18. **Elyonurus** Humboldt & Bonpland ex Willdenow.

Elyonurus Humb. & Bonpl. ex. Will .Sp. Pl. 4. 941. 1805; Hook. f. Fl. Brit. Ind. 7:161. 1897.

About 15 species, occurring in the tropics and sub-tropical regions of the world. They form "important grazing grasses in the savannah and plains of tropical America"—Bews (1929).

Elyonurus royleanus Nees ex Rich. Tent. Fl. Abyss. 2:474. 1851; Hook f. Fl. Brit. Ind. 7:161. 1897.

Jumna ravines near Agra, Duthie (Herb. Dehra.) Itmadpur, Agra;

Duthie (Herb. Dehra.) Etawah, Duthie (Herb. Dehra). Distributed in the Upper Gangetic Plain, Rajasthan, South India; also in Cape Verde and Ethopia.

Tribe 3. MAYDEAE.

A small tribe hardly more than a subtribe of the Andropogoneae.

Zea Linn.

Zea Linn. Sp. Pl. 971. 1753; Hook. f. Fl. Brit. Ind. 7:102. 1897.

A monotypic genus of American origin, now introduced into the Old World.

Zea mays Linn. Sp. Pl. 971. 1753; Hook. f. Fl. Brit. Ind. 7:102. 1897; (Hindi: Makka, Makai; The Maize or the Indian Corn plant.)

Cultivated in the area and also throughout the tropics.

A excellent fodder for cattle. Immature cobs (Bhutta) are roasted and eaten.

Besides the above mentioned grasses the following are also cultivated to a lesser extent in the area :—

1. *Avena sterilis* Linn. var. *culta* Linn.
2. *Bambusa* sp.
3. *Dendrocalamus* sp.
4. *Thysanolaena maxima* Ktze.

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STUDIES ON THE TEMPORAL REGION IN THE SKULL OF SKINKS, *LYGOSOMA INDICUM INDICUM* (GRAY) AND *MABUYA DISSIMILIS* (HALLOWELL)*

By JAGDISH PRASAD, *Lecturer in Zoology, Government Hamidia College, Bhopal.*

The lizards described here were collected from the hilly tracts of Bhopal. The skulls were cleared by maceration and by Cantuel's (2) method of boiling in a 5% solution of ammonium carbonate. Fixed whole mounts were mordanted in iodized alcohol, treated with O. 2N KOH for a fortnight and stained in a solution of alizarin red S (Sodium alizarin monosulphate) in 1% KOH. They were stored in pure glycerine with a crystal of thymol as an antimould.

OBSERVATIONS

i) *Lygosoma indicum indicum* (Gray)

The number of bones in the skull is small and as such their disposition in the temporal space is significant. The fusion of the post-orbital, post-frontal and supra-temporal result in the formation of a complex bone, which with the disappearance of the post-fronto-squamosal arcade obliterates the supra-temporal fossa. Judging from its position and relation with the surrounding bones, the fused bone represents the post-latero-frontal (post-orbital), the post-frontal and the supra-temporal bones. It extends far behind between the processus-parietalis and an arch formed by the union of the jugal and the squamosal or the so-called supra-temporal arch, as in *Lygosoma* the other components (post-fronto-squamosal) of the supra-temporal arcade atrophy. The complex bone thus occupies the same position as that of the supra-temporal fossa in other lizards. It should be noticed that this fused bone, of which the post-orbital is also one of the constituents, does not interfere with the approach of the jugal to the squamosal as in other saurians, where this sort of obstacle by the post-orbital has been observed. The lateral or the infra-temporal fossa is spacious, as the jugal and the quadrate are far apart. The jugal lies at the anterior and the quadrate at the posterior end of this fossa. The so-called supra.temporal arch (the jugal +the squamosal) bounds the infra-temporal fossa above. There is, however, no infra-temporal arcade since the bone between the jugal and quadrade or the quadrato-jugal is absent, and as such the infra-temporal fossa opens freely below. In one of the macerated skulls, a minute bone has been observed attached to the lower end of the jugal pointing towards the condylus-mandibularis of the quadrate. It may, therefore, be taken as representing the remnant of the anterior end of the quadrato-jugal. This protuberance of the quadrato-jugal in the whole mount preparation is deeply stained with alizarin and confirms the fact observed in the macerated skull.

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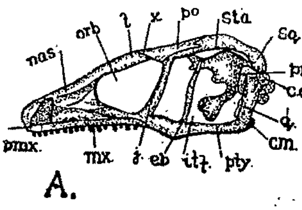
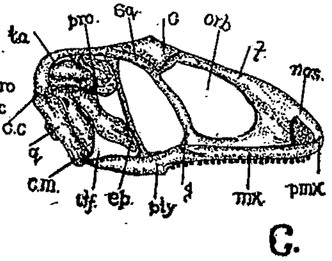
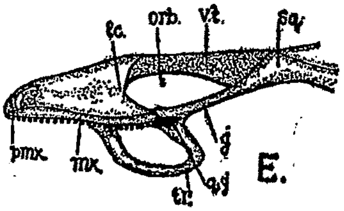
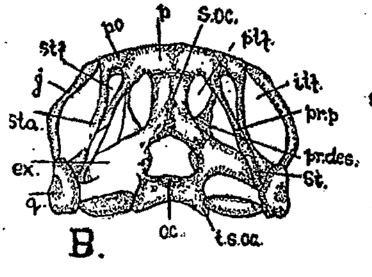
*Contribution No. 4 from Zoology Department, Government Hamidia College, Bhopal.

The post-temporal fossa or the foramen retro-temporalis of Siebenrock is very small and narrow due to the development of the prootic of the auditory apparatus. It is surrounded by the processus-parietalis and the lateral ridge of the supra-occipital laterally, the exoccipital and the processus-paroticus posteriorly and the fibrous union of the supraoccipital









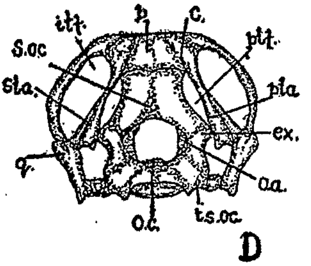


Fig. A. : Lateral view of the skull of *Mabuya dissimilis* (Hallowell) x 4.
Fig. B. : Posterior view of the skull of *Mabuya dissimilis* (Hallowell) x 6.
Fig. C. : Lateral view of the skull of *Lygosoma indicum indicum* (Gray) x 5.
Fig. D. : Posterior view of the skull of *Lygosoma indcum indicum* (Gray) x 6.
Fig. E. : Vento-lateral view (in part) of the skull of *Lygosoma indicum indicum* (Gray) showing the ramnant quadrato-jugal. x 10. ab. auditory bulla. c. complex bone. cc. condylus cephalicus. cm. condylus mandibularis. ep. epipterygoid ex. exoccipital. f. frontal. itf. infra-temporal fossa. j. jugal. lc. lacrymal. mx. maxilla. nas. nasal. oc. occipital condyle. orb. orbit. p. parietal. pmx. premaxilla. po. post-orbital. pro. prootic. prdes. processus descendens of parietal. prp. processus parietalis. pta. post-temporal arcade. pty. pterygoid. q. quadrate. qj, ramnant of quadrato-jugal. soc. supra occipital sta. supratemporal arcade. stf. supra-temporal fossa. sq. squamosal. ta. temporal arcade. tsoc. tuberculum spheno-occipitale. tr. transpalatine. vf. ventro-lateral extension of frontal. x. process to represent post-orbital.

and the parietal anteriorly. The post-temporal arcade is formed by the union of the processus-parietalis and the para-occipital process of the exoccipital joining the condylus-cephalicus of the quadrate. This arch together with the so-called supra-temporal arch and the intermingling complex bone form a compact area that result in the formation of a single temporal arcade. Thus it is a well established fact that there are two temporal fossae (the lateral and the post-temporal) the supra-temporal or the upper fossa is replaced by the complex bone. As regards the temporal arches there is actually a solitary temporal channel or passage which is divided into two arches by the hinder extension of the complex bone. The vestigial quadrato-jugal is found adhering to the jugal, occupying the same position as the fully formed anterior end of the quadrato jugal in other reptiles.

(ii) *Mabuya dissimilis* (Hallowell).

In lizards the supra-temporal fossa is always larger than the foramen-retro-temporalis, but in skinks either the supra-temporal fossa is completely aborted or smaller than the post-temporal fossa. The supra-temporal may be equal to it, but never larger than the post-temporal fossa. The supra-temporal fossa is bounded externally by the supra-temporal arch (contributed by the post-orbital and the squamosal). There exists no post-fronto-squamosal arch to participate in the formation of the upper arcade as in some lizards. Posteriorly the supra-temporal fossa is bounded by the post-temporal arch formed by the posterior lateral process of the parietal, the supra-temporal bone and a part of the pleuro-occipital process of the exoccipital. The post-orbital represents in it the merging of the post-frontal also, as it sends a process towards the frontal bone. The post-orbital does not intervene the approach of the jugal with the squamosal as in *Lygosoma indicum indicum* (Gray). The supra-temporal, however, is a distinct minute splint-like bone, separating the squamosal from the supra-temporal process which meets the dorsal head of the quadrate. The supra-temporal fossa has always two prominent bones in this respect lying each in the internal and external position. The inner upper bone is called the supra-temporal or pterotic or tubular and the outer lower one collaborating with the post-orbital (+post-frontal) is squamosal, although it has many termonological references such as the para-squamosal, para, quadrate and even quadrato-jugal.

The post temporal fossa lie essentially behind the supra-temporal one and is larger than the latter. The post-temporal arcade, however, is very distinct. Anteriorly the parietal and the processus-parietalis, posteriorly, the oto-occipital process of the exoccipital, while the ridges of the supra occipital and a part of the oto-sphenoid enclose it laterally. The infra or the lower temporal fossa lies extended between a well developed jugal and the quadrate. The jugal and the post-orbital (+post-frontal) together with the supra-temporal arch and the quadrate surrounds this large vacuity on all the sides except the ventral where due to the absence of the quadrato-jugal the arch is in-complete below. There are three distinct temporal fossae. The supra-temporal fossa is smaller than the post-temporal one, the latter being still reduced than the lateral temporal fossa. Both the temporal, arches, the supra and the post-temporals, are easily recognised.

DISCUSSION

The family Scincidae typifies the tendency towards the elimination of the supra-temporal fossa and its arcade, by way of either complete atrophy or reduction and modification in other fossae and arcades that persist, Pearson (3), while tracing the later stages in the *Lygosoma* embryo, recorded the enormous development of the pro-otic bone upto the processus-paroticus far behind the limits of the auditory capsule. He attributed this development of the pro-otic together with the quite close approach of the post orbital to the lateral edge of the parietal as the reason for the disappearance of the supra-temporal fossa upto that ontogenic stage which he studied. However, my observations on the full-grown specimen of *Lygosoma indicum indicum* (Gray) revealed that it is the formation of the complex bone by the fusion of the post-frontal, the post-orbital and the supra-temporal which obliterates the supra-temporal fossa entirely. Thus my studies are not in agreement with that of Pearson who claims the formation of the supra-temporal fossa in adult stage of Lygosoma, as also by Ramaswami, (1952) in *Lygosoma punctatum*. The enlarged pro-otic makes a difference in narrowing down the size of the post-temporal fossa. There is only a single temporal arcade as in synapsidan varities. Due to the demarcation of the bones *Lygosoma* appears to have two temporal arcades (supra and post-temporal arches) fused as a compact mass. The third temporal arcade is in a vestigial form, being represented by the so-called remnant quadrato-jugal. Rao and Ramaswami (4) reported the absence of the post-orbital in *Lygosoma punctatum*. Their researches when coupled with a fused post-orbital of the complex bone in *Lygosoma indicum indicum* (Gray) adduce coroborative evidence of the disappearance of the post-orbital bone in the sub-family Lygosominae. Broom (1) described the chondrification in *Mabuya Zonurus*, and *Eremias*. He did not mention anything about the temporal space in this account. The reduction in the size of the supra-temporal fossa in *Mabuya dissimilis* (Hallowell) in contrast to a large fenestra superior of *Mabuya carinata* (4) is a very interesting feature conclusive to the fact that the upper fossa definitely develops at a very late ontogenic stage in this lizard contrary to a condition found in *Lygosoma indicum indicum* (Gray). In *Mabuya carinata*, Rao and Ramaswami (4) referred the post-frontal and a post-orbital as separate bones. The fusion of the post-orbital and the post-frontal in *Mabuya dissimilis* like that of a complex bone in *Lygosoma indicum indicum* supports the view that the bones of the temporal region are very compact and affect the number of temporal fossae and arcades. Thus one can only conclude that lizards are representatives of the modified parapsidan skull, and it is rather difficult to group them within any of the six types classified by Versluvys (7) in his admirable resume of the reptilian skulls.

SUMMARY

1. The supra temporal fossa is entirely absent in *Lygosoma indicum indicum* (Gray) throughout the life. It is reduced in size in *Mabuya dissimilis* (Hallowell).

2. The bones of the temporal space are compact and vary in number. Their actual constituents are determined in relation to the neighbouring bones.

3. The single temporal arcade, remnant quadrato-jugal, and narrow post-temporal fossa in *Lygosoma indicum indicum* (Gray) are peculiar features.

4. The surpa-temporal is an important bone fused in *Lygosoma indicum indicum* (Gray). with the complex bone while separate in *Mabuya dissimilis* (Hallowell). In the latter there are two temporal arches and three temporal fossae.

5. In both the cases the absences of the post-fronto-squamosal arches as an integral part of the supra-teporal arcade is worth recording. Moreover, in both skinks the union of the squamosal and jugal is uninterrupted.

I am deeply indebted to Dr. P. N. Mathur Professor of Zoology, Government College, Ajmer who suggested the problem and guided the work, and to Dr. Ravi Prakash, Prof. of Zoology Govt. Hamidia College, Bhopal for help and critcism. I also owe a debt of gratitude to Dr. Shanker Dayal Sharma, Chief Minister, Bhopal State, for encouragement and facilities.

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CONDENSATION OF MALON-o-, -m-AND p-CHLORANILIC ACIDS WITH ALDEHYDES

PART III. WITH o-, m-, AND p-NITRO BENZALDEHYDES

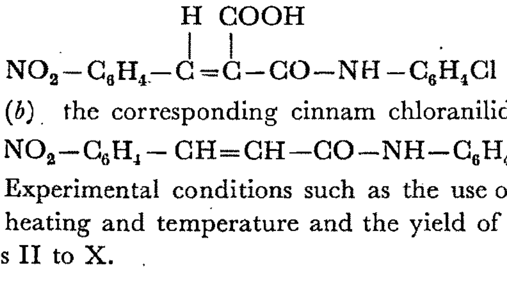
By M. V. GEORGE and P. I. ITTYERAH,

Chemistry Department, St. John's College, Agra.

Lock and Bayer (5) have made a systematic study of the formation of o-, m- and p- nitro cinnamic acids from o-, m- and p-nitrobenzaldehydes using Perkin's method. These aldehydes were condensed with malonic acid by Pandya and his collaborators(2,4,7), who reported the catalytic effect of a trace of pyridine in these reactions. Ahluwalia, Haq and Ray (1), Mehra and Pandya. (6) and Ittyerah and Pandya (3) recorded their observations on the condensation of these aldehydes with malonanilic acid.

The present paper deals with the condensation of the above mentioned aldehydes with malon-o-, m- and p-chloranilic acids. As expected, two products were isolated in each case.

(*a*) the corresponding benzylidene malon chloranilic acid



$$NO_2-C_6H_4-\overset{\overset{H}{|}}{C}=\overset{\overset{COOH}{|}}{C}-CO-NH-C_6H_4Cl$$

(*b*) the corresponding cinnam chloranilide

$$NO_2-C_6H_4-CH=CH-CO-NH-C_6H_4Cl$$

Experimental conditions such as the use of various condensing agents, time of heating and temperature and the yield of products obtained are given in tables II to X.

When no condensing agent is used or when acetic acid is used the product is wholly of type (*a*). Traces of organic bases, used as condensing agents or traces of the acetates of the organic bases, induce decarboxylation and the products are of the type (b). Piperidine is not found helpful, as a lot of resinous matter is formed when it was used.

Among the three aldehydes the meta isomer is the most reactive and of the catalysts used, pyridine acetate and piperidine acetate were the most effective.

EXPERIMENTAL

The usual procedure had been to mix equimolecular quantities of the acid and aldehyde in a flask and heat on a water bath for four hours. When a trace of an organic base was used as a condensing agent, it was added in 0.15

molar proportion, whereas acetic acid was used in one molecular proportion. After heating, the contents of the flask were extracted with a strong solution of sodium bicarbonate. The acid products were dissolved by the alkali. The non acid residue left was purified by recrystallisation from organic solvents like alcohol or acetone. To the alkali extract when hydrochloric acid was added, the acid products were reprecipitated, which were further purified by recrystallisation from alchohol or acetone.

Generally the products were either pale yellow or yellow in colour. All the products were analysed and identified and the results are shown in Table I.

SUMMARY.

The three mononitro benzaldehydes were condensed with malon-o, m- and p- chloranilic acids. In each case two products were formed, which were isolated and identified-(*a*) the corresponding benzylidene-malon-chloranilic acid and (*b*) the corresponding cinnam chloranilide. Among the three aldehydes the meta isomer was found to be most reactive and of the catalysts used pyridine acetate and piperdinc acetate were the most effective.

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TABLE I

No.	Name	Molecular Formula	m. p. (oC)	Eq. wt.		Nitrogen%	
				Found	Calculated	Found	Calculated
1.	o-Nitrobenzylidene malon-o- chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	183(d)	345.7	346.6	8.22	8.07
2.	o-Nitrocinnam-o-chloranilide	$C_{15}H_{11}O_3N_2Cl$	195			9.41	9.25
3.	o-Nitro benzylidene-malon-m-chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	186(d)	346.8	346.6	8.23	8.07
4.	o-Nitrocinnam-m-chloranilide	$C_{15}H_{11}O_3N_2Cl$	192			9.49	9 25
5.	o-Nitrobenzylidene-malon-p- chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	196(d)	347.9	346.6	8.12	8.07
6.	o-Nitrocinnam-p-chloranilide	$C_{15}H_{11}O_3N_2Cl$	168			9.38	9.25
7.	m-Nitro benzylidene malon-o- chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	212(d)	350.3	346.6	8.03	8.07
8.	m-Nitro cinnam-o-chloranilide	$C_{15}H_{11}O_3N_2Cl$	176			9.49	9.25
9.	m-Nitrobenzylidene-malon-m- chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	215.5(d)	345.6	346.6	8.21	8.07
10.	m-Nitrocinnam-m-chloranilide	$C_{15}H_{11}O_3N_2Cl$	189			9.44	9.25
11.	m-Nitrobenzylidene-malon-p- chchloranilic acid	$C_{16}H_{11}O_5N_2Cl$	206(d)	348.7	346.6	8.19	8 07
12.	m-Nitrocinnam-p-chloranilide	$C_{15}H_{11}O_3N_2Cl$	236			9.42	9.25
13.	p-Nitrobenzylidene-malon-o-chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	213(d)	346.0	346.6	8.23	8.07
14.	p-Nitrocinnam-o-chloranilide	$C_{15}H_{11}O_3N_2Cl$	219			9.22	9.25
15.	p-Nitrobenzylidene-malon-m-chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	217(d)	347.7	346.6	8.34	8.07
16.	p-Nitrocinnam-m-chloranilide	$C_{15}H_{11}O_3N_2Cl$	195			9.41	9.25
17.	p-Nitrobenzylidene-malon-p-chloranilic acid	$C_{16}H_{11}O_5N_2Cl$	218(d)	347.8	346.6	8.19	8.07
18.	p-Nitrocinnam-p-chloranilide	$C_{15}H_{11}O_3N_2Cl$	227			9.33	9.25

TABLE II—Yields of products from the Condensation of malon-o-chloranilic acid with o-nitro benzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	o-nitro benzylidene-malon-o-chloranilic acid			o-nitro cinnam-o-chloranilide		
					%yield	m.p.	Colour	%yield	m.p.	Colour
1.	Nil	1:1	4	100	43.1	183°C(d)	Yellow	0		
2.	Acetic acid	1:1:1	4	100	58.5			0		
3.	Pyridine	1:1:0.15	4	100	0			67·0	195°C	Pale Yellow
4.	Piperidine	1:1:0.15	4	100	0			14·1	,,	,,
5.	2:4-Lutidine	1:1:0.15	4	100	0			17.6	,,	,,
6.	Collidine	1:1:0.15	4	100	0			42.3	,,	,,
7.	Triethanolamine	1:1:0.15	4	100	0			24.6	,,	,,
8.	Pyridine acetate	1:1:0.15	4	100	0			70.5	,,	,,

TABLE III—Yields of products from the Condensation of malon-m-chloranilic acid with o-nitro benzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	o-nitrobenzylidene-malon-m-chloranilic acid			o-nitrocinnam-m-chloranilide		
					%yield	m. p.	Colour	%yield	m. p.	Colour
1	Nil	1:1	4	100	40.0	186°C(d)	Pale yellow	0		
2	Acetic acid	1:1:1	4	100	55.4	,,	,,	0		
3	Pyridine	1:1:0.15	4	100	0			69.1	192°C	Yellow
4	Piperidine	1:1:0.15	4	100	0			14.1	,,	,,
5	2:4 Lutidine	1:1:0.15	4	100	0			42.3	,,	,,
6	Collidine	1:1:0.15	4	100	0			42.3	,,	,,
7	Triethanolamine	1:1:0.15	4	100	0			14.1	,,	,,
8	Pyridine acetate	1:1:0.15	4	100	0			70.5	,,	,,

TABLE IV—Yields of products from the Condensation of malon-p-chloranilic acid with o-nitrobenzaldehyde.

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	o-nitro benzylidene-malon-p-chloranilic acid			o-nitrocinnam-p-chloranilide		
					%yield	m. p.	Colour	%yield	p.	Colour
1	Nil	1:1	4	100	36.9	196°C(d)	Yellow	0		
2	Acetic acid	1:1:1	4	100	61.6	,,	,,	0		
3	Acetic acid	1:1:0.15	4	100	64.7	,,	,,	0		
4	Pyridine	1:1:0.15	4	100	0			77.6	168°C	Yellow
5	Piperidine	1:1:0.15	4	100	0			Charred	,,	,,
6	2:4-Lutidine	1:1:0.15	4	100	0			28.2	*	,,
7	Collidine	1:1:0.15	4	100	0			35.3	,,	,,
8	Triethanolamine	1:1:0.15	4	100	0			28.2	,,	,,
9	Pyridine acetate	1:1:0.15	4	100	0			81.1	,,	,,

TABLE V—Yields of products from the Condensation of malon-o-chloranilic acid with m-nitrobenzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	m-nitrobenzylidene-malon o-chloranilic acid			m-nitrocinnam-o-chloranilide		
					%yield	m. p.	Colour	% yield	m. p.	Clour
1	Nil	1:1	4	100	45.2	212°C(d)	Pale yellow	0		
2	Acetic acid	1:1:1	4	100	61.6			0		
3	Pyridine	1:1:0.15	4	100	0			70.6	176°C	Pale yellow
4	Piperdine	1:1:0.15	4	100	0			56.4	"	
5	2:4-Lutidine	1:1:0.15	4	100	0			49.4	"	
6	Collidine	1:1:0.15	4	100	0			56.4	"	
7	Triethanolamine	1:1:0.15	4	100	0			42.3	"	
8	Pyridine acetate	1:1:0.15	4	100	0			81.1	"	

TABLE VI—Yields of products from the Condensation of malon-m-chloranilic acid with m-nitro benzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temper-ature (°C)	m-nitrobenzylidene-malon-m-chloranilic acid			m-nitrocinnam -m-chloranilide		
					%yield	m. p.	Colour	%yield	m. p.	C lour
1	Nill	1:1	4	100	61.6	215.5°C (d)	Yellow	0		
2	Acetic acid	1:1:1	4	100	80.1	,,	,,	0		
3	Acetic acid	1:1:1	8	100	80.1	,,	,,	0		
4	Pyridine	1:1:0.15	4	100	0			88.2		
5	Piperidine	1:1:0.15	4	100	0			88.2	189°C	Yellow
6	2:4-Lutidine	1:1:0.15	4	100	0			56.4	,,	,,
7	Collidine	1:1:0.15	4	100	0			42.3	,,	,,
8	Triethanol-amine	1:1:0.15	4	100	0			42.3	,,	,,
9	Pyridine acetate	1:1:0.15	4	100	0			89.6	,,	,,
10	Piperidine acetate	1:1:0.15	4	100	0			89.6	,,	,,
11	Piperidine acetate	1:1:0.15	8	100	0			89.6	,,	,,

TABLE VII—Yields of products from the Condensation of malon-p-chloranilic acid with m-nitrobenzaldehyde.

Exp. No.	CONDITIONS				PRODUCTS					
					m-nitro benzylidene-malon -p-chloranilic acid			m-nitrocinnam -p-chloranilide		
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	%yield	m. p.	Colour	%yield	m. p.	Colour
1	Nil	1:1	4	100	46.2	206°C(d)	Pale yellow	0		
2	Acetic acid	1:1:1	4	100	67.8	"	"	0		
3	Pyridine	1:1:0.15	4	100	0			74.1	236°C	Yellow
4	Piperidine	1:1:0.15	4	100	0			63.4	"	"
5	2:4-Lutidine	1:1:0.15	4	100	0			21.2	"	"
6	Collidine	1:1:0.15	4	100	0			35.3	"	"
7	Triethanolamine	1:1:0.15	4	100	0			21.2	"	"
8	Pyridine acetate	1:1:0.15	4	100	0			82.6	"	"

TABLE VIII—Yields of products from the Condensation of Malon-o-chloranilic acid with p-nitrobenzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	p-nitro benzylidene-malon-o-chloranilic acid			p-nitrocinnam -o-chloranilide		
					%yield	M. P.	Colour	%yield	m. p.	Colour
1	Nil	1:1	4	100	30.8	213°C(b)	Pale yellow	0		
2	Acetic acid	1:1:1	4	100	40.1	,,	,,	0		
3	Acetic acid	1:1:1	6	100	40.1	,,	,,	0		
4	Pyridine	1:1:0.15	4	100	0			77.6	219°C	Yellow
5	Piperidine	1:1:0.15	4	100	0			67.1	,,	,,
6	2:4-Lutidine	1:1:0.15	4	100	0			28.2	,,	,,
7	Collidine	1:1:0.15	4	100	0			49.4	,,	,,
8	Triethanolamine	1:1:0.15	4	100	0			42.4	,,	,,
9	Pyridine acetate	1:1:0.15	4	100	0			81.2	,,	,,
10	Piperidine Acetate	1:1:0.15	4	100	0			81.2	,,	,,

TABLE IX—Yields of products from the Condensation of malon-m-chloranilic acid with p-nitrobenzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condencing agent.	Molecular proportion	Time (hours)	Temperature (°C)	p-nitro benzylidene-malon m chloranilic acid			p-nitrocinnam-m-chloranilide		
					%yield	m.p.	Colour	%Yield	m.p.	Colour
1	Nil	1:1	4	100	49.3	217°C(d)	Yellow	0		
2	Acetic Acid	1:1:	4	100	73.9	,,	,,	0		
3	Acetic Acid	1:1:1	8	100	73.9	,,	,,	0		
4	Pyridine	1:1:0.15	4	100	0			81.2	195°C	Yellow
5	Piperidine	1:1:0.15	4	100	0			74.1	,,	,,
6	2:4-Lutidine	1:1:0.15	4	100	0			56.5	,,	,,
7	Collidine	1:1:0.15	4	100	0			42.4	,,	,,
8	Triethanolamine	1:1:0.15	4	100	0			35.3	,,	,,
9	Pyridine acetate	1:1:0.15	4	100	0			84.7	,,	,,
10	Piperidine acetate	1:1:0.15	4	100	0			81.2	,,	,,
11	Piperidine acetate	1:1:0.15	8	100	0			81.2	,,	,,

TABLE X—Yields of products from the Condensation of malon-p-choloranilic acid with p-nitrobenzaldehyde

Exp. No.	CONDITIONS				PRODUCTS					
	Condensing agent	Molecular proportion	Time (hours)	Temperature (°C)	p-nitro benzylidene-malon-p-chloranilic acid			p-nitrocinnam-p-chloranilide		
					%yield	m.p.	Colour	%yield	m.p.	Colour
1	Nil	1:1	4	100	46.2	218°C(d)	Yellow	0		
2	Acetic acid	1:1:1	4	100	61.6	,,	,,	0		
3	Acetic acid	1:1:1	6	100	61.6	,,	,,	0		
4	Acetic acid	1:1:1	8	100	61.6	,,	,,	0		
5	Pyridine	1:1:0.15	4	100	0			74.1	227°C	Yellow
6	Piperidine	1:1:0.15	4	100	0			70.4	,,	,,
7	2:4-Lutidine	1:1:0.15	4	100	0			49.4	,,	,,
8	Collidine	1:1:0.15	4	100	0			35.3	,,	,,
9	Triethanol-amine	1:1:0.15	4	100	0			35.3	,,	,,
10	Pyridine acetate	1:1:0.15	4	100	0			82.6	,,	,,
11	Piperidine acetate	1:1:0.15		100				81.2	,,	,,
12	Piperidine acetate	1:1:0.15	6	100	0			81.2	,,	,,

EFFECT OF BROMO GROUP ON OPTICAL ROTATORY POWER IN DERIVATIVES OF REYCHLER'S ACID

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The general effect of halogens on optical rotatory power of organic compounds was noticed early by Tchugaeff (1), Cohen (2) and Hilditch (3). Their work led to the view that, in general, introduction of halogens raises the value of optical rotatory power and that this value tends towards a constant in higher members of the series. These were empirical results and lead to little theoretical consequence. Later workers, particularly, Betti (4), Rule and Smith (5) and Singh (6) came to realise that the polarity of the substituent group has an effect on the magnitude of rotatory power. It was found that in general the replacement of a hydrogen in an optically active compound by a positive substituent displaces the rotation in the opposite sense to that due to a negative substituent. It was pointed ont by Singh and Barat (7) that a positive group exhibits an increase in rotation and a negative group a decrease in rotation (6).

Thus we find that there are two views in literature about the effect of halogens on optical rotatory power. According to earlier workers the effect is an increase in the rotatory power. On the other hand, later workers found that polar effect is traceable on optical rotatory power and substitution of electronegative halogen should lead, in general, to a decrease in rotatory power. In order to test the validity of these views the authors have studied in this paper the effect of replacement of hydrogen by bromine on the optical rotatory power of amine derivatives of Reychler's acid. In a previous communication (8) the effect of chloro group was studied and in this paper the work has been extended to the bromo group.

Experimental

Reychler's D-comphor-β-sulphonic cacid was prepared from natural D-camphor essentially according to the method of Reychler (9) and anilino-D-camphor-β-sulphonate according to the method described by one of us (10). p-Bromoanilino-D-camphor-β-sulphonate was prepared in the manner described by B. K. Singh *et al* (11).

2:4: 6-*Tribromoanilino-D-camphor-β-sulphonate*:—A trial preparation showed that the product is similar in properties to 2:4: 6-trichloroanilino-D-camphor-β-sulphonate. 3.3 g. 2:4:6-tribromoanilino and 2.32 g. D-camphor-β-sulphonic acid were condensed in alcohol and moisture-free ethyl acetate. It was recrystallised from ethyl alchohol when very fine white needle-shaped crystals were obtained. Yield 2.9 g., M. P. 121°.

The product is very soluble in acetone, chloroform, methyl alcohol, less so in ethyl alcohol and sparingly soluble in benzene. It is practically insoluble in water.

Found Br = 42.64 % ; S = 5.82 %
$C_{10}H_{15}OSO_3HH_2NC_6H_2Br_3$ requires Br = 42. 70 % ; S=5·69 %

A preliminary study to note the effect of temperature was carried out by noting rotations for Hg 5461 in different solvents at two temperatures not such differing from room temperature. Results are recorded in Table I

TABLE I. Influence of temperature

Formula $R=C_{10}H_{15}OSO_3H$	Solvent	Conc. in g/100 ml	Temp. in °C	Sp. rotation for Hg 5461
$R.H_2\,N.C_6H_5$	Water	0.9784	16.5	21.94
			21.0	21.94
$R.H_2N.C_6H_4Br$(p–)	Pyridine	1.0000	15.5	29.50
			25.0	29.50
$R.H_2N.CHBr_3$(2:4:6)	Et. OH	0.9336	15.5	23.00
			30.0	23.00

The rotatory power determination were carried out in a 2dcm tube and the observations are recorded in Table 2.

TABLE Rotatory power of 2: 4:6—tribromoanilino-D-camphor-β-sulphonate
Temperature 15·5° C

Concentration in ethyl alcohol 0.9336g. /100 ml
,, ,, chloroform 1.1440g. /100 ml
,, ,, pyridine 0.9848g. /100 ml

Source of light	Wave length selected (λ)	Specific rotation in solvent		
		Ethyl alcohol	Chloroform	Pyridine
Mercury vapour lamp	Hg 5780	+19.28°	+17.48°	+19.29°
	Hg 5461	23.00	21.08	22.30
	Hg 4358	36.40	...	36.08
Sodium vapour lamp	Na 5893	18.21	15.73	17.76
Neon discharge tube	Ne 6402	16.06	13.11	15.23

The data given in Table II was analysed graphically by plotting the reciprocal of rotation against square of wave length employed. A straight line was obtained in each case pointing to a simple dispersion. Rigorous mathematical analysis revealed that the dispersion can be expressed by a simple one term Drude's equation as in the case of o-, m- or p-bromoanilino—D-camphor-β-sulphonate (11).

DISCUSSION

Table I showst hat the there is no change of rotation of the compounds studied in this paper in the range 15°—30° approximately. It indicates that the temperature coefficient of rotation in this range is negligible. Anilino—D—camphor—β—sulphonate (10) and ortho, meta and para-bromoanilino—D—camphor—β—sulphonate (11) have been studied previously and shown to exhibit simple dispersion. Here it has been shown that 2 : 4 : 6—tribromoanilino-D-camphor-β-sulphonate also exhibits simple dispersion in ethyl alcohol, chloroform and pyridine. Therefore, we can compare the rotatory power of these substances in the region studied in this paper, that is, the visible region. Table III shows the values of specific rotation for Hg5461 for these substances in different solvents.

TABLE III Comparison of rotatory power

Name of compound	Specific rotation for Hg 5461 in solvent		
	Ethyl alcohol	Chloroform	Pyridine
Anilino-D-camphor-β-Sulphonate (10)	+36.40°	+45.30°	+38.10°
p-Bromoanilino-D-camphor-β-sulphonate (11)	32.00	43.00	40.00
o-Bromoanilino-D-camphor-β-Sulphonate (11)	35.00	32.00	40.00
m-Bromoanilino-D-camphor--B-sulphonate (11)	34.00	45.00	37.00
2 : 4 : 6-Tribromoanilino-D-camphor-β-sulphonate	23.00	21.08	22.30

From Table I it is clear that with the exception of p-bromoanilino-D-camphor-β-sulphonate and o-bromoanilino-D-camphor-β-sulphonate in pyridine there is a uniform decrease in the magnitude of rotation as hydrogen is being replaced by the electronegative bromine. The decrease is specially marked in the case of 2 : 4 : 6-tribromoanilino-D-camphor-β-sulphonate where three hydrogen atoms have been replaced by three bromine atoms. Mono substituted aniline derivatives exhibit an anomalous behaviour in pyridine which is a basic solvent having a dielectric constant 12.4 The importance of the effect of solvent was recognised ever since the appearance of Biot's memoir on tartaric acid in 1832. Earlier works of Walden (12), Nernst (13), Meldrum and Turner (14) were first systematised by T. S. Patterson (15). Rule and his coworkers (16) first clearly brought out the importance of dielectric constant of the solvent and the role of association on the optical activity of organic compounds in solution. Pyridine being a basic polar solvent, it might be expected to interefere with the influence of the polarity of groups on optical rotatory power. Nevertheless, when the number of electronegative groups increase as in the case of 2 : 4 : 6 tribromoanilino-D-camphor-β-sulphonate, the polar influence of substituent groups predominates and the result is a uniform marked decrease in the magnitude of optical rotatory power.

CONCLUSION AND SUMMARY

In the case of aromatic amine derivatives of Reychler's acid the rotatory power shows, in general, a decrease when electronegative bromine is substituted in place of hydrogen in the aromatic nucleus. The decrease becomes uniformly more marked if the number of electronegative bromo groups is increased from one to three. The rotatory power is studied in ethly alcohol, chloroform and pyridine in the visible region.

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THE EFFECTS OF CERTAIN SYNTHETIC GROWTH REGULATORS ON THE PROCESS OF VERNALIZATION OF *SESAMUM INDICUM* L.

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Leopold and Guernsey (2) have found that pretreatment of seeds with certain auxins, followed by a short period of chilling, results in an abbreviation of the vegetative cycles of plants raised from such seeds. Chakravarti and Pillai (1) recorded an extra earliness in flowering in mustard plants from seeds, vernalized after treatments with certain growth regulators, over those from untreated vernalized ones. The present paper deals with the results of a similar treatment in *Sesamum indicum* L.

Experiments were carried out with seeds of Type 10. Indolylacetic (IAA), a-naphthaleneacetic (NAA), 2, 4-dichloro-phenoxyacetic (2, 4-D) and 2, 3, 5-tri-iodobenzoic acids (TIBA) were used in concentrations of 50, 0.5 and 0.005 ppm. in distilled water. Seeds were soaked in tap water or in the above solutions for a period of 12 hours. Adhering moisture or solutions were removed with a clean dry towel. Then they were wrapped in moist cloth in separate dishes and chilled in a refrigerator at 2-6°C, for 3 weeks. The seeds were occasionally examined and moistened with water, if necessary. At the end of the chilling treatment, they were allowed to attain the room temperature. Only unsprouted ones were sown. Seeds soaked either in water or in solutions of the chemicals for a period for 12 hours were maintained as controls. All the sowings were done in 10″ pots filled with well manured garden soil. There were four pots for each of the variables with four to five plants. Date of opening of the first flower from the first-formed bud was recorded for an individual. Average time taken from sowing to anthesis (vegetative cycles) was clalculated for each treatment and presented in the table given below.

Analysis of variance of the data indicates that the treatment effect is not statistically significant

It would be seen from the table that in *Sesamum* neither ordinary nor chemical vernalization is effective, when unsplit seeds are used for sowing. Like vernalization, chemical vernalization too does not appear to be universally applicable. Though Leopold and Guernsey (2) and Chakravarti and Pillai (1) obtained positive results with the crops with which they worked, Vieitez (3) failed to record any earliness in flowering in maize plants raised from seeds treated with IAA and then chilled for different periods.

My thanks are due to Dr. S. D. Sharma, Chief Minister, Bhopal for his kindly making available to me a research grant and also to Principal P. C. Malhotra for offering me necessary facilities to carry out this piece of investigation.

Table

Vegetative cycles of plants raised from seeds treated with different concentrations of growth regulators and then chilled. (Chemical vernalisation).

Treatments			No. of plants	Vegetative cycle in days
Chemical	Conc.	Chilling		
Water	———	Yes	18	32.4
,,	———	No	20	31.9
IAA	50 ppm.	Yes	12	33.2
,,	,, ,,	No	15	32.6
,,	0.5 ,,	Yes	17	31.8
,,	,, ,,	No	20	30.2
,,	0.005 ,,	Yes	13	30.4
,,	,, ,,	No	14	30.1
NAA	50 ,,	Yes	18	32.8
,,	,, ,,	No	17	31.6
,,	0.5 ,,	Yes	15	33.4
,,	,, ,,	No	14	31.8
,,	0.005 ,,	Yes	20	34.0
,,	,, ,,	No	20	33.9
2,4-D	0.5 ,,	Yes	18	32.6
,,	,, ,,	No	15	32.8
,,	0.005 ,,	Yes	15	34.0
,,	,, ,,	No	14	31.8
TIBA	50 ,,	Yes	18	32.9
,,	,, ,,	No	19	32.8
,,	0.5 ,,	Yes	17	30.1
,,	,, ,,	No	14	34.2
,,	0.005 ,,	Yes	18	32.5
,,	,, ,,	No	17	31.0

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ANALYSIS OF RADIO FREQUENCY PULSES GENERATED IN SILENT A. C. DISCHARGES

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Abstract

The measurement of magnitude and intensities of frequency bands and discrete pulses generated in discharge tubes of various types, ozonisers, 'sleeve' discharge tubes, and tubes with external electrodes, has been carried out, using a Wen frequency meter. Ozonisers and other tubes contained iodine and other vapours and were excited suitably by voltages of 50 c. p. s. The frequency meter, used in these investigations is essentially a wave meter of absorption type. It has much higher sensitivity due to incorporated amplifier and the resonance condition is observed on an indicating meter. The instrument was employed to study the structure of the current in the main circuit and aerial. An additional rectifying circuit using 1 N 34 germanium crystal diode and a sensitive reflection galvanometer was employed to study the sensitivity of the pulses to radiation.

The detailed investigation showed that the r. f. oscillations formed a continuous band of frequencies akin to "electrical noise" or the production of white light, consisting of photons of varied frequencies from an incandescent bulb. The discharge tube served as a low power transmitter of general radiations. Some discrete frequency pulses and their harmonics were also recorded, but they were characteristic of the tuned circuit rather than of the discharge itself. By continually varying the condenser position in the tuned circuit, a continuous variation of the discrete pulses was observed ; a particular resonant circuit picking up the resonance frequency from the continuous e. m. spectrum generated by the discharge tube.

Introduction

That the current passing through an ozoniser subjected to a. c. discharge is not simple but very complex in nature, consisting of a large number of pulses of frequencies much different from the fundamental frequency, was pointed out for the first time by warburg (11). In a series of experiments on behaviour of gases under ozoniser discharge, he measured the current by finding out the potential fall across an ohmic resistance with the help of an electrometer and also by a thermo junction. It was found that the current strength measured by thermocouple was much greater than that measured by the electrometer. This divergence in the two values was attributed by Warburg to the existence of high frequency currents produced during the discharge in the ozoniser, which only in part could pass through the resistance and in part, conducted to the earth across the electrometer capacity; while the current in entirety was deducted by the thermo junction.

The origin of high frequency oscillations was explained by Klemenc, Hintenberger & Hoffer (4) as follows :—

On the application of the electrical field, the ions produced in the gas phase move towards the glass walls and build up surface charges. When the alternating potential falls to the zero value, the charges on the surface become free to neutralise with each other, leading to the production of sparks, which are responsible for observed oscillations.

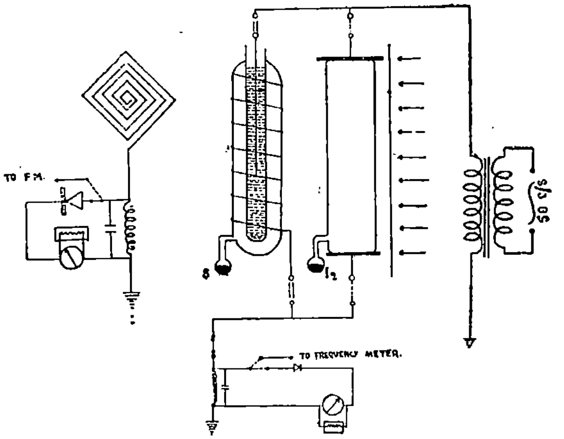

Fig. 1. Diagram of the general experimental arrangement.

With the help of oscillographic data these authors pointed out that the h. f. currents consisted of great many impulses, which shoot from the main current trace with apparent disposition of unidirectional pulses and a "veil-like patch" on the oscillographic screen, rather than high frequency oscillations, as originally thought of, by warburg and others (11). Deb & Ghosh (1) extended this view to explain the phenomenon.

Deb and Ghosh (1) suggested that neutralisation occurs on the surface of the walls, leading to the production of pulses. Marathe and others observed that these h. f. pulses corresponded roughly to Trichel (10) pulses. Essentially similar data was recorded by Harries & Von Angel (2).

The present investigation deals with the detection and analysis of various freqencies generated in the electrodeless a. c. discharges and the association of Joshi Effect with them.

EXPERIMENTAL

The general experimental arrangement is represented diagrammatically in fig. 1. Two important pieces of equipment have been used in these investigations:

1. *The crystal detector*: Germanium crystal diode IN 34 Sylvania U.S.A. was used as a rectifier, with a very long range of rectification (frequencies from 0 to 150 mcs) and is reported to have a uniform rectification characteristic over various frequency ranges.
2. *The WEN Frequency meter*: This instrument has been employed to measure the magnitude and approximate intensities of various discrete frequency pulses and bands. The apparatus has the following specifications :—Make: Rohde Schwarg, Germany. Frequency range: 10 Kc. to 30 Mcs. (Broken down into 7 bands) Accuracy :=±·50% Input sensitivity : = 5m v. to 20 v.

The meter is essentially a wave meter of absorption type. A tunable resonant circuit is fed with a signal at the unknown frequency while the resonance condition is observed on a indicating meter. It has a much higher sensitivity due to an incorporated amplifier.

Discharge tubes of various types (ozonisers, cylindrical tubes with external electrodes, tubes with external sleeves etc.) were employed. They were excited under various applied voltages of 50 c.p.s. and the discharge current was observed when the vessel was in dark (i_D), and when irradiated (i_L) from an incandescent sodium vapour lamp, placed in side a chamber with pulley-operated shutter. From these the net Joshi Effect $\triangle i = (i_D - i_L)$ and percentage Joshi Effect $\frac{\triangle i}{iD} \times 100$ were calculated. The intensities of various frequency bands were also recorded employing known constants of the frequency meter. This indication is only approximate, due to the fact that the voltage sensitivity decreases with higher frequency input.

Three types of experiments were carried out :

Section A: Measurement and detection of discrete frequency pulses and frequency bands in the main current, using parallel resonant circuit of known L C values. The potential developed across these circuits was measured after rectification and alternatively it was fed to the frequency meter to detect the presence of high frequency pulses. The inductances and capacities were varied so as to alter the resonance frequency pulse detected in the discharge current. A typical set of observations at these applied potentials is presented in tables I to VI (using tubes filled with iodine and sulphur vapours) and represented graphically in fig. 2.

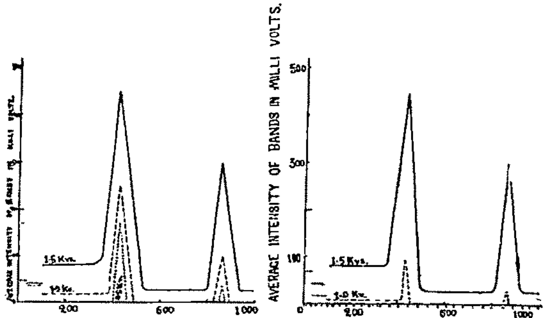

Fig. 2. Graph showing the results of observations at various applied potentials; graph on left *in the dark*; on right *under irradiation.*

Section B : Studies of frequency pulses in the main current when non inductive, non capacitative resistances were employed in the low tension line. The potential developed across these pure resistances was fed to the detecting circuit and the frequency meter as in section A. A typical set of observations is contained in table VII and represented graphically in fig. 3.

In *Section C*, studies of frequency pulses were carried out in aerial currents, using parallel resonant circuits as in section A. The discharge tube works as a low power transmitter of e. m. radiations and hence the radiation could be picked up by a frame aerial kept closed to the discharge tube- Observations are recorded in table VIII and represented graphically in fig. 4.

RESULTS AND DISCUSSIONS

1. A glance at tables I to VI and the corresponding graph (fig. 2.) shows that the frequency band from 10 Kc. to 30 Kc. is the most powerful band present in the discharge current at any applied potential. As the potential applied to the discharge tube increases, the intensities of the various pulses present in the discharge current increases; 10 Kcs. to 30 Kc. band still being the most prominent band. The intensity of the first band (10 Kc. to 30 Kc.) at 2 k v. is 90 m v., but increases to 200 m v. at 3.5 k v. (*vide* table I). This is to be expected in view of the fact that the discharge tube works as a transmitter of general radiations, and therefore the energy output should increase with higher working potentials.

2. Some discrete frequency pulses have been recorded. From fig. 2 it is clear that the 415 kcs. & 830 kcs. frequency pulses exist in the main discharge current. The value of these discrete frequency pulses alter by altering the parallel resonant circuit. It is thesefore, contemplated that these frequency pulses are the ***resonant pulses*** of the system, which fact is borne out by actua calculations. The values of the frequency measured by frequency meter agree well with those calculated from the constants of the circuit. Harmonics of the resonant frequency pulses have been detected in some cases. For example the frequency 415 kc. is present in the discharge and also frequency pulse of double its value (*vide* table V fig. No. 2.). The calculated and observed values of frequencies employing various circuits have been tabulated in table IX.

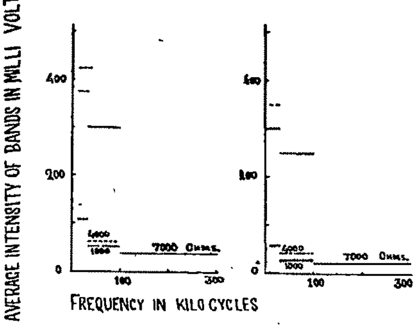

Fig. 3. Graph showing typical set of observations of frequency pulses in the main current when non-inductive, non-capacitative resistances were employed in low tension line. Left in dark, right under irradiation.

Discrete oscillations in D. C. gas discharges were long known from the theoretical and experimental works of Penning (5), Webb and Pardue (12)

Tonks and Langmuir and others (9). It is to be emphasised that these workers utilised discharge tubes which have gases at comparatively high pressure (few mms.). These oscillations are referred to as plasma electron and ion oscillations, Barkhausen Kurtz oscillation and noise oscillations. These oscillation were characterstic of the discharge itself and depended on the magnitude of the applied voltage, distance between the electrodes and the gas pressure.

The tables I to VI and IX clearly indicate that discrete oscillations recorded by authors are independent of the applied voltage, nature of the discharge tube, electrode distance, gas in the discharge tube, etc., and hence can have no similarity with the aforesaid oscillations, These discrete pulses depend *only upon the nature of the resonant circuit employed,* the intensity of which increasing with the applied potentials. Detailed investigation "shows that the r. f. pulses formed a continuous band of frequencies akin to electrical noise" or the production of white light consisting of photons of varied frequencies from an incandescent bulb.

A particular resonant circuit picks up a particular frequency out of white radiations and that appears as a discrete frequency.

Similar views were already expressed by one of us (7). However Khastgir and others (3) have detected discrete oscillations in low frequency a. c. discharges, which they attribute to the discharge itself and explain their origin on a theory akin to that of B. K. oscillations. These workers employed ozonisers, containing iodine vapour, hydrogen, nitrogen gases and also "sleeve discharge" tubes filled with hydrogen, chlorine and iodine vapour.

A long vertical copper wire connected to a coil wound on each tube was used as a radiating antenna. A T.R.F. receiver or a receiver of superhet type worked with a receiving T aerial was employed to detect the R.F. oscillations. For a given distance between the electrodes, it was found that the frequency of any one of the r. f. oscillations remained practically constant over a wide range of applied voltage. It was also found that for a fixed applied voltage the frequency of the r.f. oscillations was independent of the distance between the electrodes.

It is to be doubted whether these reported frequencies by Khastgir and others, are characterstic of the discharge, as they are independent of the applied voltage, the distance between the electrodes and nature of the gas. It is felt that they are only the resonance frequencies reported by one of us (A.P.S.) and discussed in this paper. Actual calculations (by taking a few micro henry as the inductance of the coil wound on each tube and a few micro/micro farad as the associated capacity of the radiating antenna and its associates) give us the resonance frequency pulses of the order, reported by Khastgir and others.

3. When a non inductive, non capacitative resistance is used in the low tension line, these discrete frequency pulses disappear, though the various bands are still present with much reduced strength (*vide* table VII, fig. 3)

If these discrete pulses were characterstic of the discharge, they should have been detected even when an ohmic resistance was used in the low tension line. The intensities of these pulses would only have been reduced on account of damping caused by the ohmic resistance. This therefore provides an additional *decisive proof* of the non existence of discrete pulses as characterstic of low frequency electrodeless discharge.

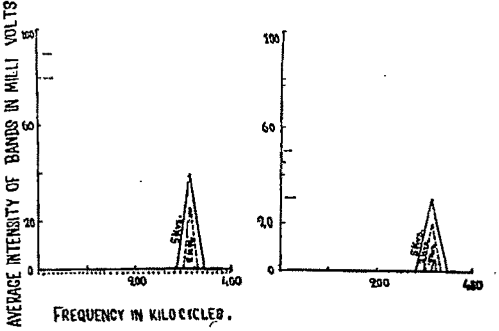

Fig. 4. Graphs showing observations of frequency pulses in aerial current, using parallel circuits. Left in dark, right under irradiation.

4. Studies of Joshi Effect in these frequency pulses present an intresting data. (table I to VI and the corresponding graph in fig. 2.) Near V_m when the discharge attains a self maintained character, the photosuppression of the frequency bands and discrete pulses is practically cent per cent. The corresponding i_D, i_L, Δi, $\% \Delta i$ values are in close conformity with the above observations, indicating also 100% suppression. For example at potential ·5 k v., i_D is 5 units i_L is O and $\% \Delta i$ is 100% and the intensities of the frequency bands are also reduced to zero under irradiation (cf. table V). As the potential is raised, the intensity of pulses and current in dark enhance while their photo suppression diminishes. For example, at potential 1·5 k v. i_D and $\% \Delta i$ are 125 units and zero respectively (cf.table V fig. 2).

The association of Joshi Effect may be traced to the high frequency pulses. It is interesting to note that the high frequency pulses are compeletely suppressed under irradiation at V_m but are practically insensitive to light at higher potentials, though they are present in much greater strength. The generation of the high frequency pulses is therefore a characteristic of the discharge but their light sensitivity is a function of the applied voltage. Any explanation of the Joshi Effect must take into account this curious behaviour of the high frequency pulses. A review of the physical process underlying the production of these high frequency pulses shall be attempted in a later communication.

5. Studies in aerial currents confirm the deductions already arrived at, that the discharge tube works as a low power transmitter of general radiati-

ons and any frequency out of the spectrum can be picked up by suitably designing the tuned circuit. Discrete frequencies and harmonics were detected employing different tuned circuits. For example using I_2 vapour tube with external electrodes, frequency pulse 315 kc. was detected at all applied potentials but its light sensitivity decreased with the increasing potential (cf. table 8) The frequency pulses detected were characteristic of the resonant circuit and the same frequency was recorded by the meter (taking into consideration the added capacity and inductance due to frame aerial) whether the detecting circuit was employed in the main circuit or in the aerial.

Our grateful thanks are due to Dr. W.V. Bhagwat for keen interest during the progress of the work.

TABLE I.—Tube usedozoniser containing I_2 vapour

Approximate resonant frequency = 1.7 mcs. (calculated from the LC Values)

Applied Voltage	Frequency detected	Intensity in dark in mvs.	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
2 Kvs	10-30 Kcs band	90	50	12	6	6	50
	1.3 Mcs (Resonant)	60	40				
	2.6 Mcs (Harmonic)	30	0				
3 Kvs	10-30 Kcs band	110	90	52	44	8	15.4
	30-100 Kcs band	30-40	20-30				
	300-1000 Kcs band	50-200	40-160				
	1.3 mcs. (Resonant)	200	160				
	2.6 mcs. (Harmonic)	70	60				
3.5 Kvs	10-30 Kcs band	200	No change in intensity under irradiation	70	67	3	4.5
	30-100 Kcs band	30-50					
	300-1000 Kcs band	50					
	1.3 Mcs (Resonant)	200	,,				
	2.6 Mcs (Harmonic)	90	,,				

TABLE II.—Tube used as in table No. 1]

Approximate resonant frequency = 550 Kcs (calculated from the L C values)

Applied voltage	Frequency detected	Intensity in light in mvs.	Intensity in light in mvs	i_D	i_L	Δi	$\%\Delta i$
2 Kvs	10—30 Kcs band	150	100	40	30	10	25
	415 Kcs (Resonant)	250	150				
	830 Kcs (Harmonic)	150	90				
	1200 (2nd Harmonic)	20	15				
3 Kvs	10—30 Kcs band	275	No Change in intensity under irradiation	160	152	8	5
	30—100 Kcs bands)	60—90					
	100—300 Kcs band	80—160					
	415 Kcs (Resonant)	650	,,				
	630 (Harmonic)	400	,,				
	1210 (2nd Harmonic)	40	,,				
	1600 (3rd Harmonic)	20	,,				
3.5 Kvs	10—30 Kcs band	250—500	,,	250	250	0	0
	30—100 Kcs band	150—300	,,				
	100—300 Kcs band	250—500	,,				
	415 Kcs band (Resonant)	800	,,				
	830 (Harmonic)	400	,,				
	1200 (2nd Harmonic)	60	,,				
	1600 (3rd Harmonic)	30	,,				

TABLE III.—Tube used as in table No. 1
Approximate resonant frequency=660 Kcs (as calculated from L C values)

Applied Voltage	Frequency detected in Kcs	Intensity in dark in mvs.	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
2 Kvs	10-30 Kcs band	200	100	35	20	15	42.9
	510 (Resonant)	300	150				
	1000 (Harmonic)	40	25				
	1500 (2nd Harmonic)	15	10				
3 Kvs	10-30 Kcs band	500-750	No change	130	130	0	0
	30-100 Kcs band	50-100	in intensity				
	100-300 Kcs band	50-150	Under irradiation				
	510 (Resonant)	375	,,				
	1010 (Harmonic)	100	,,				
	1500 (2nd Harmonic)	40	,,				
3.5 Kvs	10-30 Kcs band	350-775	,,	190	190	0	0
	30-100 Kcs band	50-100	,,				
	100-300 Kcs band	50-150	,,				
	510 Kcs (Resonant)	375	,,				
	1030 Kcs (Harmonic)	100	,,				
	1500 Kcs (2nd Harmonic)	50	,,				
	2020 Kcs (3rd Harmonic)	10	,,				

TABLE IV.—Tube used: Ozoniser containing sulphur vapour.
Approximate reasonant frequency=1.7 mcs. (as calculated from L C values)

Applied Voltage	Frequency detected in Kcs.	Intensity in dark in mvs.	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
.5 Kvs	1300 Kcs (Resonant)	15	0	1	0	1	100
1 Kvs.	10-30 Kcs band	25	15	4	1.5	2.5	62.5
	1320 Kcs (Resonant)	25	15				
2.5 Kvs.	10-30 Kcs band	150	No change	22	22	0	0
	30-100 Kcs band	20	in intensity				
	100-300 Kcs band	20	under irradiation.				
	300-1000 Kcs band	20-50	,,				
	1300 (Resonant)	60	,,				
	2690 (Harmonic)	15	,,				

TABLE V.—Tube used as in table IV.
Approximate resonant frequency=550 Kcs. (as calculated from LC values)

Applied voltage	Frequeney detected in Kcs.	Intensity in dark in mvs,	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
.5 Kvs.	10-30 Kcs band	50	0	5	0	5	100
	415 (Resonant)	170	0				
	830 (Harmonic)	40	0				
1 Kvs	10-30 Kcs band	170	70	45	20	25	55.55
	30-100 Kcs band	40	20				
	100-300 Kcs band	20	10				
	415 (Resonant)	250	100				
	830 (Harmonic)	100	40				
1.5 Kvs	10-30 Kcs band	200	No change	125	125	0 0	0
	30-100 Kcs band	30-60	in intensity				
	100-300 Kcs band	80	under irradiation				
	300-1000 Kcs band	30	,,				
	415 (Resonant)	450	,,				
	850 (Harmonic)	300	,,				

TABLE VI. – Tube used as in table IV.

Approximate resonant frequency=660 Kcs. (as calculated from LC values)

Applied Voltage	Frequency detected in mvs.	Intensity in dark in mvs.	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
.5 Kvs.	10-30 Kcs band	40	0	4	0	4	100
	525 (Resonant)	250	0				
1 Kv.	10-30 Kcs band	100	40	30	12	18	60
	530 (Resonant)	500	300				
	1050 (Harmonic)	25	10				
1.5 Kvs.	10-30 Kcs band	180	No change	75	75	0	0
	30-100 Kcs band	40	in intensity				
	100-300 Kcs band	20-40	under irradiation.				
	530 (Resonant)	750	,,				
	1050 (Harmonic)	40	,,				

TABLE VII.—Tube used as in table IV.

Applied voltage=1.0 K.v,

Resistance in circuit in ohms.	Frequency detected	Intensity in dark in mvs.	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
1000	10-30 Kcs band	70-150	40-80	12	6	6	50
	30-100 Kcs band	40-70	20-40				
4000	10-30 Kcs band	250-600	350	20	12	8	40
	30-100 Kcs band	40-90	30-60				
7000	10-30 Kcs band	225-525	300	15	10	5	33.3
	30-100 Kcs band	200-400	250				
	100-300 Kcs band	30-50	20-30				

TABLE VII.—Tube used: Iodine tube with external electrodes.

Distance of aerial from discharge tube=50 cms.

Approximate resonance frequency=400 Kcs (as calculate from LC values)

Applied Voltage	Frequency detected	Intensity in dark in mvs.	Intensity in light in mvs.	i_D	i_L	Δi	$\%\Delta i$
.5 Kvs.	315 Kcs. (Resonant)	0	5	.5	1	.5	100%P
2 Kvs.	10-30 Kcs band	80	50	6	4	2	−33.3%
	315 Kc (Resonant)	25	20				
5 Kvs.	10-30 Kcs band	90	30	11	5.5	5.5	−50%
	315 Kc. (Resonant)	40	30				

TABLE IX.—Showing the constancy of observed discrete frequencies with the resonant frequencies (of employed LC circit) although the tube used and applied voltages differ.

Tube used	Applied voltage in kilo volts	Discrete frequency ovserved in Kcs.	Resonant frequency calculated from LC values in Kcs.
Iodine Ozoniser	2	1300	1700
	2.5	1300	1700
	3	1300	1700
	2	420	550
	2.5	420	550
	3	420	550
	2	490	590
	2.5	490	590
	3	490	590
Iodine tube with external-electrodes	0.5	465	600
	1.0	465	600
	1.5	465	600
	0.5	510	650
	1.0	510	650
	1 5	510	650
Sulphur ozoniser	.5	1300	1700
	1	1300	1700
	1.5	1300	1700
	.5	420	550
	1	420	550
	1.5	420	550
	·5	510	650
	1	510	650
	1.5	510	650

NOTE—The divergence between the observed and the calculated values (from L C values of the circuit) of discrete frequency is probably due to the insensitiveness of the valve voltmeter employed for high frequency measurements of L and C.

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PARACHOR OF NITRIC ACID

By V. G. VAIDYA, PRATAP NARAYAN AND W. V. BHAGWAT,

Chemistry Laboratory Holkar College, Indore.

Rao (8) has studied the Raman effect in solutions of nitric acid at concentrations varying from 10—65% and the progress in the electrolytic dissociation of the acid on solution has been studied by measuring changes in the intensities of the Raman Lines due to the undissociated molecules and ions. The observations of Rao as well as those of W. Gerlach, (3, 4) on Raman Spectra of crystalline and dissolved nitrates and of Krishnamurti (7) and of 1. Kishi (6) indicate that in fairly concentrated solutions nitric acid behaves as HO-NO_2 but on dilution ionization takes place. We have, in this paper, investigated into the behaviour of nitric acid at different concentrations with the help of parachor.

Pure nitric acid was prepared by distilling Merck's extra pure acid with lead peroxide and passing a current of air through the distillate till colourlesse The specific gravity of the distillate was found to be 1.498 corresponding to to 99% concentration and was confirmed by titration. The parachor of the nitric acid was calculated by applying the mixture law and the values obtained are as follows :

The symbols x, M_m. t, d, γ, P_m, and P_x have usual signiance—

%	x	M_m	Temp.	Density	γ	P_m	P_x
99	0.9692	61.60	25.2	1.498	36.76	101.3	10.29
86	0.6675	48.03	26.0	1.463	44.88	84.96	101.14
75	0.4850	39.81	25.2	1.425	54.53	75.91	101.2
70	0.3892	35.51	25.1	1.404	61.46	70.81	100.2
66	0.3649	34.42	25.0	1.387	58.29	68.57	97.73
59	0.300	31.50	25.4	1·358	63.56	65.49	96.74
57	0.2815	30.66	24.0	1.341	61.31	63.97	94.38
52	0.235	28.57	25.2	1.314	65.52	61.86	93.61
45	0.1892	26.513	25.3	1.273	67.48	59.69	92.19
39	0.1516	24.820	25.5	1.234	68.69	57.92	90.5
32	0.1240	23.581	21.6	1.199	69.00	56.67	89.0
28·5	0.1009	22.553	25.2	1.167	68.53	55.54	86.22
25	0.0846	21.807	26·0	1.381	69.29	55.25	89.36
18	0.0577	20.595	25.8	1.097	69.44	54.18	88.21

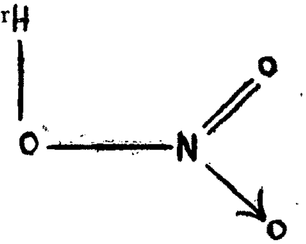
%	x	M_m	Temp.	Density	v	P_m	P_x
15	0.0479	20.136	25.8	1.081	69.88	53.75	88.81
13	0.0397	9.79	25.0	1.068	69.74	53.55	88.91
10.5	0.0319	9.43	24.8	1.054	69.30	53.18	86.2
9	0.0269	9.214	24.8	1.044	69.13	53.06	87.72
7	0.0223	8.942	24.6	1.035	69.73	52.88	87.44
5	0.0153	8.683	25.2	1.026	69.88	52.65	88.22

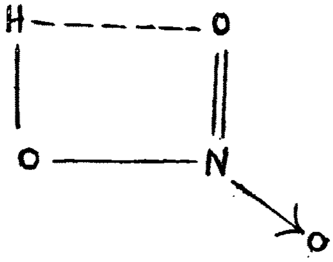
DISCUSSION.

Raman spectra of nitric acid solutions of varying concentrations as well as those on crystalline nitrates and nitrites studied by Rao and others support the view that nitric acid exists as $HO-NO_2$ in fairly concentrated solutions. It was observed by Rao that there is a Raman line for which Δi is 1310 cm. $^{-1}$ in fairly concentrated solutions of nitric acid. No such line was found with sodium nitrate but a similar line with a frequency displacement of 1400 Cm^{-1} was observed in the case of the nitrites and organic nitro compounds (5).

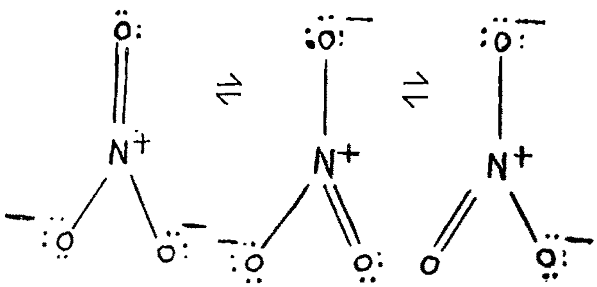
Hence sodium nitrite and concentrated nitric acid have $-NO_2$ group. On dilution with water Raman line of nitric acid at 1310 cm^{-1} displacement characteristic of NO_3 ion and occurring in Raman Spectrum of crystals and solutions of various nitrates appears with increasing intensity. This change must obviously be due to ionization.

Sugden (9) gives the value of parachor of pure nitric acid as 105.0. The $P_{calc.}$ for the undissociated molecule of nitric acid is 111.6 for the structure.



Our results show that in very highly concentrated solution (99-75%) nitric acid has a parachor of about 102 and the value goes on decreasing until it becomes almost constant at 87 below 33%. In a number of papers published from this laboratory Bhagwat (1) and co-workers have shown that there is an appreciable decrease in parachor on ionisation. This means that there is almost no ionisation of nitric acid above the concentration of 75% and almost complete ionisation of nitric acid below 33% while other concentrations stand midway between the two. Further Bhagwat (2) and co-workers have shown that there is a drop in parachor of 8—10 units due to hydrogen bonding. The difference in the $P_{calc.}$ and $P_{obs.}$ of undissociated nitric acid is of this order and can be attributed to the presence of hydrogen bond in the molecule  Yost and Russel (10) have from other considerations proposed a similar structure for nitric acid.

Our observations confirm the observations of Yost and Russel in addition to those of Rao and others that there is a nitro group present in the concentrated nitric acid solution. The big drop of 15 units in parachor on dilution to 33 % and below may be attributed to ionisation and to resonance of the nitrate ion between the structures—



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CO-ORDINATION COMPOUNDS OF NITROBENZENE AND ANILINE

By R. P. SHUKLA AND S. K. BHANDARI, *Department of Chemistry,*

Holkar College, Indore.

The behaviour of nitrobenzene and anilines rather strange as far as their dipole moment is concerned. Thus aniline and nitrobenzene have a dipole moment of 1.54 and 4.01 Debyes. When benzene is used as a solvent however, the same substances have 1.77 and 4.03 Debyes as their moment in dioxane. This effect has been attributed to solvent effect by Syrkin and Dyatkina. (4) The present work was undertaken to see if parachor can throw any light on this problem.

MIXTURE OF ANILINE IN DIOXANE

TABLE I.

$x=0.39563$ $M_m=89.973$ $1-x=0.60437.$

Temp.	'r'	'd'	P_m	P_x
23.5	26.877	1.0347	197.84	200.64
30.05	28.379	1.0269	202.21	211.69
35.5	28.491	1.0207	203.61	214.98

TABLE II.

$'x'=0.43454$ $M_m=90.152$ $1-x=0.56546$

Temp.	'r'	'd'	P_m	P_x
26.5	14.092	1.0321	169.19	134.37
32.0	23.616	1.0252	123.82	191 03
36.0	20.687	1.0198	188.49	178.77

TABLE III.

‘x’ = 0.41696 $M_m = 90.079$ $1 - x = 0.58304$

Temp.	‘r’	‘d’	P_m	P_x
23.5	24.677	1.0342	193.10	186.94
31.0	24.728	1.0262	194.67	191.83
36.5	23.436	1.0202	193.15	187.06

TABLE IV.

‘x’ = 0.31938 $M_m = 89.584$ $1 - x = 0.68062$

Temp.	‘d’	‘r’	P_m	P_x
23.5° C	1.0342	24.677	193.10	186.94
31.0	1.0262	24.728	194.67	191.83
36.5	1.0202	23.436	193.15	187.06

TABLE V.

‘x’ = 0.43351 $M_m = 90.172$ $1 - x = 0.5518$

Temp.	‘d’	‘r’	P_m	P_x
23.0	1.0318	28.675	202.30	209.30
32.3	1.0235	29.316	204.55	217.62
35.8	1.0216	27.384	201.93	209.27

TABLE VI.

‘x’ = 0.44813 $M_m = 90.217$ $1 - x = 0.55187$

Temp.	‘d’	‘r’	P_m	P_x
25.5	1.0018	28.678	202.30	209.30
32.5	1.0235	29.316	204.55	217.62
35.8	1.0216	27.384	201.93	209.27

Parachor of Nitrobenzene in Dioxane

Table VII.

‘x’=0.72387 M_m=113.692 1−x=.26613

Temp.	‘d’	‘r’	P_m	P_x
27.3	1.1617	29.567	228.19	239.82
30.0	1.1585	29.491	228.72	240.50
35.0	1.1543	29.806	229.61	241.72

Table VIII.

‘x’=0.42017 M_m=102.811 1−x=.57983

Temp.	‘d’	‘r’	P_m	P_x
27.3	1.1089	26.9423	150.48	87.700
30.0	1.1086	27.35	152.69	92.64
35.0	27.32	27.32	153.36	92.341

Table IX.

‘x’=0·22945 M_m=96·028 1—x=0·77055.

Temp.	‘r’	‘d’	P_m	Px
24.0	23.664	1.0760	196.85	199.67
30.0	24.501	1.0691	199.81	212.56
35.0	25.316	1.0656	201.93	211.82

Table X.

‘x’=0·34627 M_m=100.123 1—x=0.65373

Tem.	‘r’	‘d’	P_m	P_x
24.0	28.086	1.0988	209.70	235.61
30.0	26.816	1.0973	208.26	232.48
35.0	29.580	1.0884	214.44	249.29

TABLE XI.

'x'=0.3321 M_m=99.627 1—x=0·66789

Temp.	'r'	'd'	P_m	Px
28.0	24.232	1.0909	202.67	216.07
30.0	25.162	1.0872	205.22	223.72
35.0	31.760	1.0794	219.09	265.46

TABLE XII.

'x'=0.30993 M_m=98.73 1—x=0.69007

Temp.	'r'	'd'	P_m	P_x
26.5	26.613	1.0916	205.36	226.83
30.0	23.232	1.0857	199.62	208.93
34.5	13.748	1.0817	175.71	130.89

MOLECULAR COMPOUNDS

TABLE XIII.

A mixture of benzene in nitrobenzene.

Wt. of Benzene.	Wt. of nitrobenzene.	Temp.	'r'	'd'	P
13 2190	18.3966	26.5	32.311	1.1220	448.30
17.7582	24.5059	27.5	32.010	1.1220	447.30
11.1620	15 2894	22.7	32.010	1.223	449.00
15.6536	21-0206	22.5	32.218	1.1220	448.00
19.9884	20.2026	22.5	32,915	1.1251	449.30

TABLE XIV.

A mixture of nitrobenzene in dioxane

Wt. of Nitrobenzene	Wt. of Dioxane.	Temp.	'r'	'd'	P
15.3154	9.6182	23.2	28.180	1.0515	440.6
21.2932	13·7226	22.7	27.290	1.0537	436.3

Wt. of Nitrobenzene	Wt. of Dioxane.	Temp.	'r'	'd'	P
24.5636	15.6724	28.7	28.204	1.0515	444.0
28.1920	17.4546	22.5	27.733	1.0590	435.6

TABLE XV.

A mixture of aniline in benzene.

Wt. of Aniline	Wt. of Benzene	Temp.	'r'	'd'	P
9.4236	8.8298	23.2	32.592	1.0299	419.9
11 8796	11.2342	23.3	32.387	1.0338	417.0
13.8786	14.3894	23.3	32.479	1.0331	419.2
16.3256	15.5924	23.3	33.303	1.0347	417.7

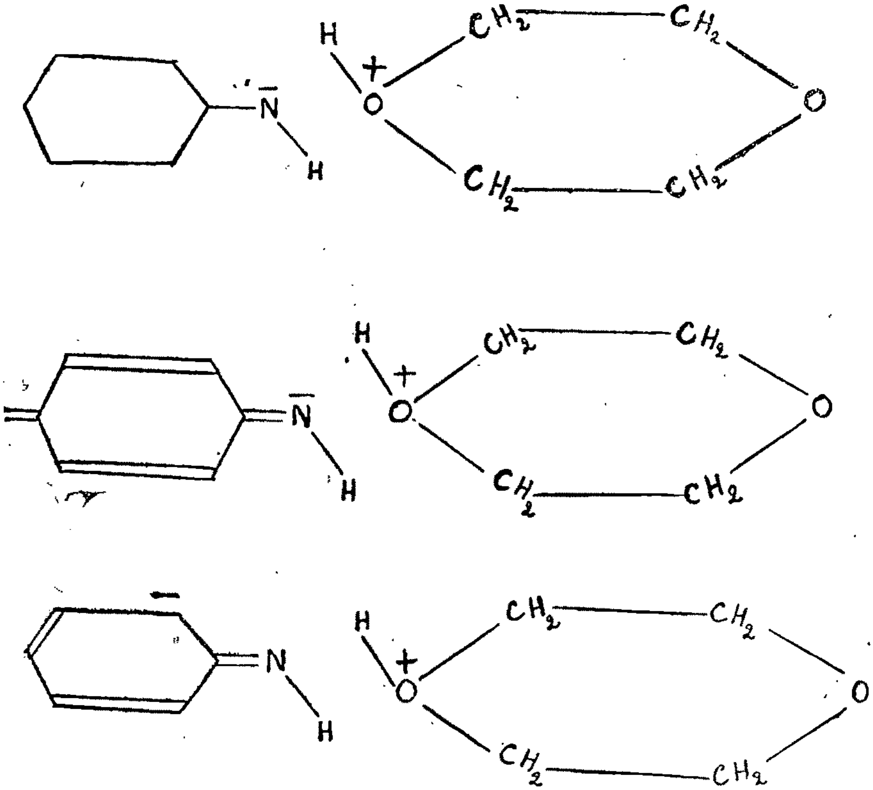
TABLE XVI.

A mixture of Aniline in dioxane.

Wt. of aniline	Wt. of dioxane	Temp.	'r'	'd'	P
9.3670	7.9800	23.5	27.836	0.64907	413.80
13.7816	11.8042	23.5	27.084	0.95147	410.00
16.1808	13.7950	23.5	27.127	0.94842	411.50
20.9522	17.7622	23.7	27.242	0.94711	412.70

It will be seen from these tables that mixture law of Hammick and Andrews fails in the case of aniline and nitrobenzene. The results are lower than what one should get. There should therefore be some type of co-ordination between these substances and the solvents used. The two pairs of substances were mixed in the ratio of their molecular weights and their parachor determined, assuming to be dealing with a single compound. As will be seen from the tables XIII—XVI, the observed parachor of a mixture of benzene and nitrobenzene came to be 448.0, while that of nitrobenzene and dioxane is 438.2. The sum of the parachor of a molecule each of benzene and nitrobenzene is 470.4, while that of nitrobenzene and dioxane and is 466.2. There is a lowering of 22.0 units in case of benzene and nitrobenzene and 28.15 units lowering in case of nitrobenzene and dioxane, thus showing co-ordnation or hydrogen bond formation in case of dioxane and nitrobenzene (2). The lowering observed in case of a mixture of benzene and nitro-benzene is due to the resonance in the molecules of the two substances (2). In case of dioxane and nitrobezene there is resonance as well as co-ordination and hence the lowering is greater.

Similar is the case of aniline in the two solvents. The lowering in case of a mixture of benzene and aniline is 23 0 units, while in case of aniline and dioxane the lowering is 28.7 units, showing the co-ordination of aniline and dioxane. Following resonating structures can be suggested in case of the co-ordination of aniline and dioxane as suggested by Surkin and Dyatkina (4):—



(i) Two Stractures (ii) Two Stractures (iii) Four Stractures

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4. Syrkin and Dyatkina. 1950. The structure of molecule and chemical Bond, Butterworth scientific Pub pp. 278

ENTOMOLOGICAL SURVEY OF THE HIMALAYA*

PART 20.—ON A COLLECTION OF ICHNEUMONIDAE (PARASITIC HYMENOPTERA) FROM THE NORTH-WEST HIMALAYA

By GERD H. HEINRICH, *Dryden, Maine, USA and* V. K. GUPTA, *School of Entomology, St. Johns College, Agra, India*†.

Patroclus maculitarsis (Cam).

1903. *Myermo maculitarsis*, Cameron *Ann. Mag. nat. Hist.* **11** : 317/18
Holotype : in Coll. Brit Mus., London.
Terra typica: Khasia Hills

One single female specimen collected at Manali, 6500 ft, Kulu Valley. The species was recorded before from Khasia Hills and North Burma. Thus it seems to be spread over the whole Himalaya from the North-West to its far eastern prolongations.

Triptognathus subalpinus Heinr.

1949. *Triptognathus subalpinus*, Heinrich, *Mitt. Munch. Ent. Ges.* **35-39** : 47/48 [1945-49]
Holotype: in coll. II G.H. Heinrich.
Terra typica: Berchtesgaden, Bavarian Alps, 5000 ft.

3 females from Dhorni, 12000 ft, Chandra Valley. The discovery of this first recently described alpine species in the high mountain region of the N. W. Himalaya is zoogeographically interesting. The specimens were compared with the type and found to be identical except for an almost unmeasurable difference in width of the broadest joints of flagellum which seem to be a very little bit wider in the Himalayan population. This difference however, was considered to be too trivial for possibly being used even as a subspecifical character.

Most sepecies of the genus *Triptognathus* are ecologically characterised as inhabitants of grassy mountain and high mountain slopes.

Ichneumon americanicolor, spec. nov.

Holotype: Female, Dhorni, 12000 ft, Chandra Valley, N. W. Himalaya, coe 1. V. K. Gupta; in the National Collection of the Zoological Survey of India, Calcutta.

A genuine and typical species of the genus with colour pattern which are not represented in Europe but common among nearctic Ichneumon species. The strong hair of head and thorax and the morphology of flagellum corresponds with many boreal forms.

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*Contribution No. 74 from the School of Entomology.

† Now at Zoological Survey of India, Calcutta.

Female.—Red. Scutellum yellow; Sterna, pleura and propodeum mostly and a broad basal band on tergites 2-4 black; 6th and 7th tergite with a yellow anal mark, 2nd and third with indistinctly confined yellow marks in the hind corners; flagellum red, the apical third black, without annulus. Legs red except trochanters I and II and the base of all coxae which parts are black.

Thorax black with the following parts being red: the whole mesonotum, collar, broad upper and narrow lower margin of pronotum, squamulae, tegulae, postscutellum, areae spiraculiferae and on one side only a mark in the lower half of the hind part of mesopleurae.

Length 11 mm.

Head and thorax with rather long brownish hair.

Head transverse. Temple profile seen from above rounded and hardly narrowed behind eyes. Cheek profile in front view rather strongly and in straight line narrowed towards base of mandibles. Vertex from the hind margin of eyes and ocelli roundly and slowly sloping backward without forming a sharp edge. Malar space distinctly longer than the width of mandible base. Face and especially frons and vertx strongly and densely punctured. Middle field of face hardly raised and weakly separated from the clypeus.

Mandibles slender with 2 small teeth, the upper being too much longer than the lower.

Flagellum long, slender filiform, neither broadened beyond middle nor attenuated, with 38 joints, its first joint being less than 1-1/2 times longer than at the apex wide, seen from above about the 8th being as long as at the apex wide, no joint wider than long except the last 8 joints before the end ones which are slightly transverse.

Mesonotum rather flat, very strongly and densely punctured. Scutellum smooth and shining, flat above, hardly raised above the level of postscutellum.

The horizontal part of propodeum at the middle considerably shorter than the area posteromedia, the area superomedia being slightly transverse. Abdomen strongly oxypygeous, terebra slightly prominent. Postpetiole with sharply defined middle field, distinctly aciculated all over. Gastrocoeli shallow, almost triangular, their interval at least as wide as one of them; 2nd tergite densely and distinctly punctured all over, the 3rd finely punctured in the basal half becoming gradually smoother towards the apex.

Legs normal, slender. Coxae III smooth and glossy below with only few scattered punctures and a feeble scopula.

ENTOMOLOGICAL SURVEY OF THE HIMALAYA*

PART XVIII—NOTES ON SOME INSECTS COLLECTED BY THE SECOND ENTOMOLOGICAL EXPEDITION TO NORTH WEST HIMALAYA, WITH DESCRIPTION OF THREE NEW SPECIES OF COLLEMBOLA

By SANTOKH SINGH, H. N. BAIJAL AND KOSHY MATHEW, *School of Entomology, St. John's College Agra.*

This paper is a report on a part of the collections of insects brought back from the high altitudes, especially beyoned the timber line in Lahoul-Spiti by the Prof. Mani School of Entomology Second Entomological Expedition to North-West Himalaya, 1955. We thank Prof. M. S. Mani for facilities, and for guidance.

SECTION A By Santokh Singh

Order COLEOPTERA

Family Carabidae

Calosoma maderae auropunctatum (Herbst)

1784. *Carabus auropunctatum*, HERBST., in *Arch. Ins.- gech.* (Fuessly) 5 p. 131.

1929. *Calosoma maderae auropunctatum*, ANDREWES, FBI., Coleop. Carabidae, 1 : 58

4 Examples, Coll. No. 9.2/55-9.4/55, 9.6/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Rahla, 8835 ft., Coll. Santokh Singh, 25. v. 1955". Sta. No. 10. Cardex 12.

4 Examples, Coll. No. 121. 2/55-121.5/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Rahla 8835 ft. Coll. V. K. Gupta 28. v. 1955." Sta. No. 8 and Cardex 23.

6 Examples, Coll. No. 220.1/55-25.6/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Rahla 9000 ft., Coll. H. N. Baijal, 26. v. 1955." Sta No. 12. Cardex 14.

5 Examples, Coll. No. 77.1/55-77.5/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Kulti Nal, 11,600 ft., Coll. Santokh Singh, 9.vi. 1955." Sta. No. 29 Cardex 68.

1 Example, Coll. No. 326.1/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Kote (Kulu Valley) 7,500 ft., Coll. V. K. Gupta, 20.vi. 1955". Sta. No. 6 and Cardex 102.

Previously known from Northern and Central Europe, Central Asia, Kulu, Lahaul, Sumdeo, Patseo, Sisu; Keylling, Cimur, and Rotang Valley;

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*Contribution No. 71 from the School of Entomology, published with the permission of the Professor of Zoology & Entomology. An earlier note on the insects collected by the Second Expedition was published as Part XIV of the series in *Agra Univ. J. Res.* (Sci.) 4 (Suppl.) : 741. 1955. All the collections of the insects dealt with here have been deposited in the Zoological Survey of India, Calcutta.

Chamba; Banu; Kashmir. Sonemarg 8600 ft.; Kogyar, Sind Valley, Dras, Kargil and Leh; U.P. Chakrata Distt.

Calosoma maderae kashmirense Breum

1927. *Calosoma maderae kashmirense*, BREUNING, *Mon.*, 1:216
1929. *Calosoma maderae kashmirense*, ANDREWES, FBI. , Coleop. Carabidae. 1: 60

2 Examples, Coll. No. 9.19.1/55,9.5/55, "Prof M. S. Mani School of Entomology Epedition to Himalayas. Rahla 8835 ft.; Coll. Santokh Singh, 1955." Sta. No. 10 and Cardex 12.

1 Example Coll. No. 170.10/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Gramphu, 12,000 ft.; Coll. V. K. Gupta, 8.vi. 1955". Sta. No. 24 and Cardex 62.

1 Example Coll. No. 312. 1/55, "Prof M. S. Mani School of Entomology Expeditian to Himalayas; Dhorni, 12,000 ft. Chandra Valley; Coll. V. K. Gupta, 13. vi. 1955". Sta. No. 32 and Cardex 77.

Previously known from Punjab Kulu; Rotang Valley and Lahaul Sumdeo Kashmir; Tibet.

Calosoma maderae indicum Hope

1831. *Calosoma indicum*, HOPE *Zool. Misc.*, 21
1229. *Calosoma maderae indicum*, ANDREWES FBI., Coleop. Carabidae, 1:61.

2 Examples Coll. No. 326.2/55, 539.2/55, "Prof. M. S. Mani School of Entomology Exepedition to Himalayas; Kote, 7500 ft. Kulu Valley ; Coll. V. K. Gupta and Santokh Singh respectively, 20. vi 1955". Sta. No. 6 and Cardex 102,103.

Previously known from Nepal; North India; N.W.F.P.; Punjab: Bajaura, Spiti, Tsho-ti, Kulu, Pulga; Kashmir : Srinagar; Bengal: Calcutta; Bihar: Pusa, Chapra; U. P. : Dehra Dun.

Craspedonotus himalayanus Sem.

1910. *Craspedonotus himalayanus*, SEMENOV, *Rev. Russe Ent.*, 216.
1935. *Craspedonotus himalayanus*, ANDREWES, FBI., Coleop. Carabidae, 2 : 39.

2 Examples Coll. No. 580.1/55,580. 2/55, "Prof M. S. Mani School of Entomology Expedition to Himalayas; Manali, 6500 ft.; Coll. Santokh Singh, 25.vi. 1955" Sta. No. Near 5 and Cardex 117.

Previously known from N.W.F. P.: Chitral, Lut Koh Valley, Izh; Punjab: Kulu, 5000-7000 ft. Kangra, Baddia, Parbati Valley, 6000-8000 ft.; U. P. Dehra Dun.

Chaetobroscus anomalus Chaud.

1878. *Broscus anomalus*, CHADOIR,, *Bull. Mosc.* 2 : 1
1935. *Chaetobroscus anomalus*, ANDREWES, FBI., Coleop. Carabidae, 2 : 43.

2 Examples Coll. No. 137.2/55, 137.3/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas; R. Beas Bank near Marhi, 11,000 ft.; Coll. V. K. Gupta, 31.v. 1955". Sta. No. 16 and Cardex 32.

Previously known from Punjab Lahaul, Spiti and Rotang Valley, Seraj, Jalori Pass 10,800 ft.; Kashmir Nagaberan, 10,000 ft., Baltal, Khilanmarg. 10,000 ft. Gulmarg, Shishram Nag, 12,000 ft. and Lidarwat 9000 ft., Goorais Valley, Sind Valley; Chamba; Dalhousie; Bashahr: Sionrin behind Chini.

Section B. By Koshy Mathew

Order HOMOPTERA

Family CICADIDAE

Cryptotympana corvus (Walk)

1850. *Fidicina corvus*, WALK *List Hom* **1** : 86

1906. *Cryptotympana corvus* DISTANT , *Fauna Brit. India*, Rhynchota Heteroptera, Homoptera) **3** : 81

1 Example, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Ramgarh, 7000 ft. Coll. H. N. Baijal 17-X-1953.

Lateral margins of pronotum greyishly pilose, metanotum with two central and four lateral greyish spots, three spots at the anterior margin of face, femora and posterior tibia and opercula raddish ochraceous. in all other charcters the specimen agree well with the published descriptiou of the species. The species is previously known from Sikhim, Darjiling, Sylhet, Assam, Naga Hills and Nilgiri Hills.

Sena quaerula (Pall)

1773. *Cicada quaerula*, PALL *Reise* **2** : 729

1906. *Sena quaerula*, DISTANT, *Fauna Brit. India*, Rhynchota Heteroptera Homoptera) **3**:135

1 Example, "Prof. M S. Mani School of Entomology Expedition to Himalayas, Ramgarh 7000 ft. Coll. Koshy Mathew, 18-X-1953.

Head with the front and a large broken transverse fascia between the eyes ochraceous, abdomen black with the postorior segmental margins ochraceous, the face, sternal spots, shading to femora, tibia and tarsi ochraceous rostrum with its apex ochraceous. In all other characters the specimen agrees with the published description of the species. Previously recorded from Quetta Distributed over a considerable portion of the Palaearctic Region, Turkistan, Tashkent, Persia and Afghanistan.

Pycnarepanda (Linn)

1767. *Cicada repanda*, LINN. *Syst. Nat.*, (1) **2** : 707. 17

1906 *Pycna repanda*, DISTANT, *Fauna Brit. India*, Rhynchota (Heteroptra-Homoptera), **3** : 71

10. Examples "Prof. M.S. Mani School of Entomology Expedition to Himalayas, Narkanda 9500 ft. Coll. J. P. Agarwal, 4—X—1954"

The specimen agrees well with the published description of the species. Previously recorded from Kashmir Vaelly, North Bengal Darjiling, Assam, Margherita and Naga Hills, Khasi Hills, Sikhim, Sylhet, Seebsagar. Butma, Kakhien Hills.

Platylomia umbrata (Dist.)

1888. *Cosmopsaltria umbrata*, DISTANT. *Ann. Mag. Nat Hist.*, (6), **1** : 293
1906. *Platylomia umbrata*, DISTANT. *Fauna Brit. India*, Rhychota (Heteroptero. Homoptera), **3** : 103

1. Example "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chakrata 8000 ft. Coll. S. Singh, 20-X-1953."

Head and pronotum brownish ochraceous, mesonotum and metanotum obscure olivaceous. In all other characters the specimen agrees well with the published description of the species. The species is previously known from Sikhim, Assam, Naga Hills, Burma, Bhamo.

Family FULGORIDAE

Phromnia marginella (Oliv.)

1791. *Fulgora marginella*, OLIV., *Encycl. Meth.*, **6** : 575.
1906. *Phromnia marginella*, DISTANT *Fauna Brit. India*, Rhynchota (Heteroptera-Homoptera), **3** : 398.

5 Examples, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chakrata, 8000 ft. Coll. Koshy Mathew, 24-X-1953".

The specimens agree well with the published description of the species. The species is common throughout Assam, Noa Dehing Valley, Sikhim, Darjiling, Ceylon, Kandy. Tenasserim. Mergui.

Family MEMBRACIDAE

Tricentrus aeneus (Dist.)

1916. *Tricentrus aeneus*, Distant, *Fauna Brit. India*, Rhynchota (Homoptera : Appendix) **6** : 167

1 example, Coll. No. 569. 4155. "Prof. M.S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu), 6000 ft., Coll. Santokh Singh, 21-VI-1955 Sta. No. 42, Cardex No. 114"

The specimen before me agrees well with the published description of the species. Previously recorded from E. Himalayas, Kurseong, Darjiling, Peshoke, Kallimpong, Ghumti, Pussimbing, Assam,Margharita, Bengal, Kumaon Almora, Tenasserim, Myitta.

Order HETEROPTERA

Family HYDROMETRIDAE

Gerris sahlbergi (Dist.)

1879. *Gerris sahlbergi*, DISTANT, *Trans. ent. S. London*, p. 125.
1903. *Gerris sahlbergi*, DISTANT, *Fauna Brit. India*, Rhynchota (Heteroptera). **2**:179

25 examples, Coll. No. 75/55," Prof. M.S. Mani School of Entomology Expedition to Himalayas, Gramphu (12,000 ft.), Kulti Nal (11,000 ft.), Coll. V. K. Gupta, H. N. Baijal & Santokh Singh, 7-VI-1955, Sta. No. 28, Cardex No. 68

In all characters the specimens agree well with the published description of the species. Previously known from Ladak, Leh.

Family LYGAEIDAE

Scolopostethus ornandus (Dist.)

1903. *Scolopostethus arnandus*. DISTANT, *Fauna Brit. India*, Rhynchota (Heteroptera). 2 : 93.

3 examples, Coll. No. 97/55. "Prof. M.S. Mani School of Entomology Expedition to Himalayas, Pir Panjal Range-opposite Kulti Nal (12,000 ft.) Coll. Santokh Singh, 10-VI-1955." Sta. No. 26, Cardex No. 73.

Head, pronotum and sceutellum black, lateral margins of promeso & metanotum pale ochraceous, corium luteous, apex of clavus and an adjoining subclaval fascia piceous, boby beneath black, antennae and legs castaneous. Previously known from Burma, Karennee.

Section C. By H. N. Baijal

Order COLLEMBOLA

Suborder **Arthropleona**

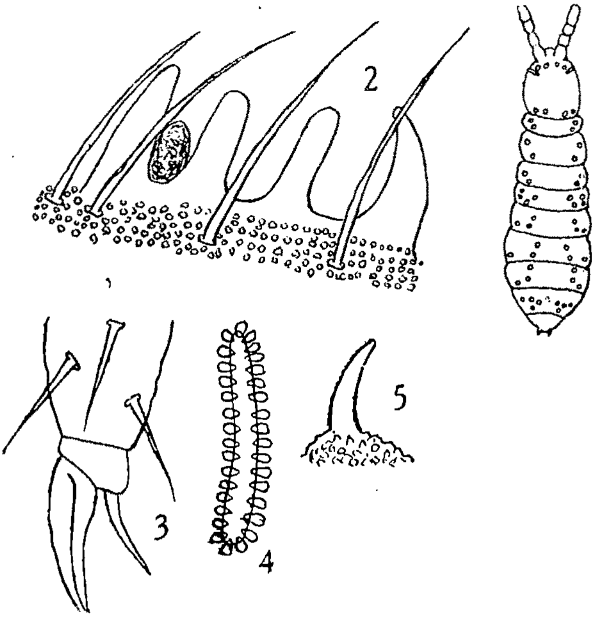
Superfamily Poduroidea

Family Hypogastruridae*

Subfamily Onychiurinae

Onychiurus kultia sp. nov.

Creamy-white. *Clothing* evenly clothed with uniform plain setae, longer



Onychiurus kultia, sp. nov. Fig. 1. Dorsal view of body. Fig. 2. Sensory organ from Ant. III. Fig. 3. Unguis and unguiculus of hind leg. Fig. 4. Post-antennal organ. Fig. 5. Anal spines,

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*This family name is adopted here pending the final decision of the International Commission on Zoological Nomenclature concerning the validity of the generic name *Hypogastrura* Bourlet, 1839.

posteriorly. Cuticle granulate. *Body* (fig. 1) Length 1.8-2mm. Antennae equal to head ; four segments related as 8 : 20 : 12 : 17. Ant. IV with a few simple setae only, no sense rods or apical knobs ; sensory organ of antennal III (fig. 2) consisting of four granulate papillae, two narrow and straight; and a single tuberculate club and guarded by four long setae. Post-antennal organ (fig. 4) with 16 simple tubercles arranged along a narrow trench Pseudocelli two on each antennal base, two on each side of posterior border of head, 2+2 on prothorax ; thorax II. 2+2 and thorax III 3+3. Abdomen I, II, III and IV 3+3 and Abdomen V 4+4. No pseudocelli on abdomen VI. Two curved anal spines present (fig. 5). *Legs* (fig. 3) similar and small. Unguis without any teeth and finelly granulate and Unguiculus slender with basal half weakly lamellate and apical half acuminate, almost reaching the tip of claw. Tenent hair absent. *Furcula* absent.

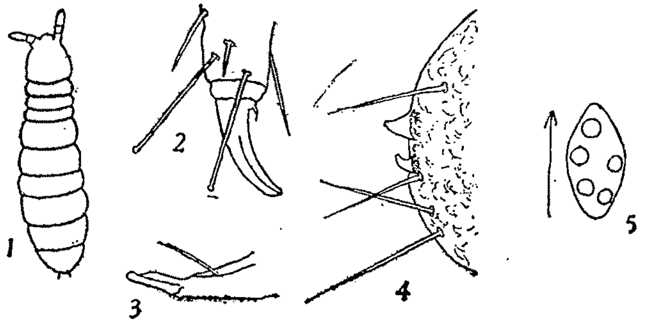
Holotype on slide Reg.No. $-\frac{589}{8\mathrm{H}}-$ and *Paratype* in spirit in tube Reg.No. $\frac{1588}{8\mathrm{H}}$ labelled "Prof. M.S. Mani, School of Entomology Expedition to Himalayas, Gramphu, 12,000 ft." under stones near the left bank of river Chandra. Coll. H. N. Baijal, 7H VI-1955. Kardex No. 46. Sta. No. 24.

This species is near t) *Onychiurus armatus* Tulberg, from which it can readily be distinguished by the number and arrangement of pseudocelli and by its antennal III sense organ. It differs from the *Onychiurus fimetarius* L.[1] trom Cooner, Kateri valley (Nilgris. S. India) and Peradeniya (Ceylon) by the presence of anal spines and number and arrangement of pseudocelli.

Subfamily Hypogastrurinae.

Xenylla sincta, sp. nov.

Deep blue-black. Mounted, a deep violet on the body and all the appendage *Clothing* sparsely clothed on body, legs and antennae with short setae, longer and somewhat numerous around the tip of the abdomen. *Body* (fig 1) Length 2-2.5 mm Antennae shorter than head without any sense organ.



Xenylla sincta. sp. nov. Fig 1. Dorsal view of body. Fig 2. Unguis of hind leg. Fig 3. Mucro and apical portion of dens. Fig 4. Anal spines. Fig 5. Ocelli of right side.

Ocelli (Fig. 5) five to each side on dark pigment patches. Two small anal spines (fig. 4) on minute papillae *Legs* (fig. 2) similar. Claw long slightly curved without any teeth. Unguiculus represented by small bristles. Two clavate tenent hairs longer than claw to each foot. *Furcula* (fig. 3) small. Dens and mucro indistinctly separated. Mucro long and blunt, with broad lamella terminating before apex. Dens with a single long setae.

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[1] *Handshin*, E. 1929. *Rev. Suisse Zool.*, **36** : 236.

Holotype on slide Reg. No $\frac{1590}{H\ 8}$ and *Paratype* in spirit tube Reg. No. $\frac{1591}{H\ 8}$ labelled "Prof. M. S. Mani, School of Entomology Expedition to Himalayas, Rahla, 8.835 ft. From moss, Coll. Santokh Singh 24-V-1955. Kardex No. 10. Sta. No. 8.

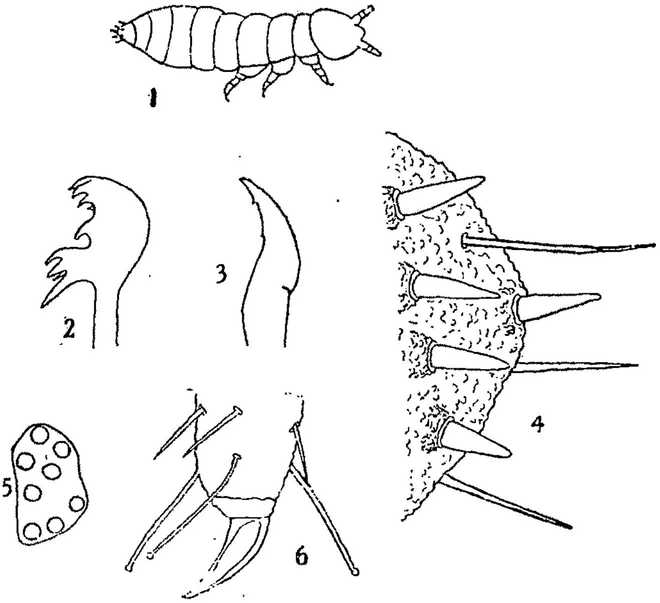
This species can easily be distinguished from *Xenylla hadialii*[2] Baijal, from Narkanda, Simla-Tibet road,near Sutlej Valley by its mucro which is blunt; Unguis without any teeth and further by presence of small bristle representing the unguiculus.

Subfamily Neanurinae

Tribe Brachystomellini

Friesea maxima, sp. nov.

Entirely bluish-black, somewhat lighter ventrally *Clothing* evenly clothed with short and plain setae but on the head and on the tip of the abdomen the setae are longer and somewhat numerous. Cuticle finely granulate and tuberculate. Body (Fig. 1) Length 2-2.5 mm. Mandible (fig. 2) with 9 teeth, posterior one being large and blackwardly directed. Maxilla



Friesea maxima, sp. nov. Fig 1. Lateral view of body. Fig 2. Mandible. Fig 3. Maxilla, Fig 4. Anal spines. Fig 5. Ocelli of right side. Fig 6. Unguis of hind leg.

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[2] *Baijal*, H. N. 1955, *Agra Univ. J. Res.* (Sci) ; 4 (2) : 532-533.

(fig. 3) reduced with apical teeth and with two small teeth. Antennae shorter than head without any sense organ and the four segment related as 9:26:9:11. Eight ocelli (fig. 5) on either side on black patch present. Post-antennal organ absent. Five strong, straight anal spines (fig. 4) present on dorsal side of the last abdominal segment, four in straight line and one at the tip of the abdomen. *Legs* (Fig. 6) claw without any teeth, with five clavate tenent hairs, three dorsal and two ventral.

Holotype on slide Reg. No. $\frac{1592}{\text{H } 8}$ and *Paratype* in spirit in tube Reg. No. $\frac{1593}{\text{H } 8}$ labelled "Prof M. S. Mani, School of Entomology Expedition to Himalayas; Gramphu 12,000 ft. Coll. H. N. Baijal, 7-VI-1955, Kardex No. 48. Sta. No.

This species is near to *Friesea coiffaiti*[3] Cassagnau and Delamare from which it can readily be distinguished by absence of teeth from claw, some what straight anal spines and lastly by its mandible. It differs from the *Friesea excelsa*[4] Denis, from Ororotse La. Top. 5500m. from ladak. N. W. Himalayas by the absence of furca.

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[3] *Cassagnau, P. and Delamare-Deboutteville, C.* 1951. Biospelogica **75** : 372.

[4] *Denis. J.R.*, 1935 *Mem. Conn. Acad. Art and Sci.* **10** : 261.

STUDIES ON THE GALL MIDGE *SCHIZOMYIA MACARANGAE* NAYAR
I—SEASONAL EMERGENCE OF THE ADULT MIDGES.

By K. Ramakrishna Pillai, *Department of Zoology, University College, Trivandrum.*

Introduction.

Considerable work has been done on the systematics and general life-history of Indian gall midges (Itonididae; Diptera) by Mani, Nayar and Rao, but no attempt has so far been made to study the fluctuation in midge populations Barnes made an extensive survey of the fluctuations in population of wheat blossom midges. He has also shown (3) how the periodic fluctuations influence the prevalence of pests, and as a result of his studies we have obtained valuable information regarding the biology, emergence rhythm, parasite complex, diapause, etc. of the midges concerned.

The present work was started with a view to study the fluctuations in populations, the biology and diapause of the common South Indian gall midge *Schizomyia macarangae* Nayar. The work was commenced in the beginning of 1955 and the present paper embodies the results of observations made on the emergence season of the year.

Material and Methods

Leaves of *Macaranga indica* with galls were collected from Trivandrum and neighbouring places of Kaladi and Karakulam on different dates in February, March and April of 1955. The galls turn yellowish-brown when full grown and show greyish pubscence all over the surface except at the point of attachment to the leaf, where it is whitish. This attachment becomes loose and galls could be dislodged at this stage by the slightest touch or by shaking. The galls were carefully examined to eliminate those from which the parasites emerged. These could be distinguished by the small perforations on their surface. The galls were then placed in separate petri dishes on wet soil and were daily observed to note the emergence of the adults. A total number of 3932 galls from 12 collections during February-March 1955, were studied. The adults were counted, their sexes noted and preserved in 70% alcohol. The parasites were also collected and separately preserved. The observations were conducted during the season of 1955 from February to August.

Observations

No emergence of the midges was seen during the months of March to June which constitute the summer. During this period however, there was fairly regular emergence of the Hymenopterous parasites from the galls. These always emerged during the forenoons mainly between 8.30 a.m. and 9.30 a. m.

The crest of the wave of emergence of parasites occurred on March 21st. The emergence of the parasites gradually declined and completely stopped by the beginning of June. A total number of fifty parasites emerged from the collections indicating approximately 1.27% of parasitism in the field during the collection period. Midges began to emerge by the beginning of June and the emergence continued till about the third week of July. It reached a peak towards the 20th of June. Daily counts were made of their number and the accompanying chart (fig. 1) shows their daily emergence during the period.

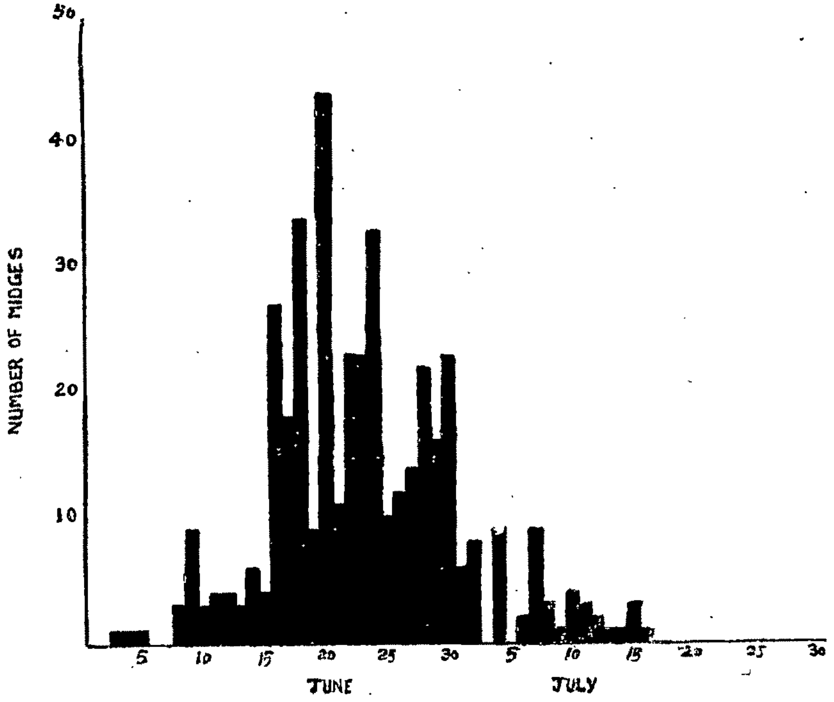

Fig. 1. Graph showing the daily emergence of *Schizomyia macarangae* Nayar in June-July 1955.

The total emergence from the entire lot is given in the table.

June and July form the period of south-west monsoon of the year, and the emergence of the adult midges occurred during this period. Unlike the parasites the midges all emerged in the afternoon, generaly between 2 p.m. and 4 p.m. All midges were normal males and normal females. The sex ratio of the midges, is approximately 50:50(Vide Table). There was complete absence of the parasites once the midges started emerging. By the third week of July the emergence of midges stopped. Only a total of 411 midges emerged from the collections representing 10·45% of the galls collected; the rest died out probably due to the attack of moulds common during the monsoon.

DISCUSSION

Nayar (7), in describing the species *Schizomyia macarangae,* observed influence of rain on the emergence of the midges. He has also noted the emergence of the midges in the afternoons and their crepuscular habits. The present investigation shows that the emergence of the midges is practically confined to the months of June and July, which form the rainy months of the south west monsoon period. The maximum emergence of the midges occured during the latter half of June, when the rains are in full swing. By this time the host plants would have produced sufficient tender foliage on which these insects could oviposit. The emergence synchronises with growth of the host plant and insures optimum conditions for oviposition.

Definite changes are produced in populations by the time of emergence of the parasites. It has been observed (1) that normally in the wheat midges, the parasites emerge later than the midges. This ensures the infestation of the midges sometime during their larval life. The parasites of the macaranga-midge emerge earlier than the midges. A similar condition was found in the parasites of *Dasyneura alopecuri* by Barnes (1). No abnormality in sex ratio has been observed.

Nayar (7) has observed that a larval quiescence was present in *Schizomyia macarangae* which could be broken by contact of water. In the present experiments it was noted that the wetting fails to bring about pupation and emergence in the summer months, which probably suggests a different physiological behaviour. Under laboratory conditions emergence of adults occurs only in the monsoon months and artificial wetting earlier does not induce pupation. If kept on drysoil, they fail to emerge even in rainy months, showing that contact of water is actually required for pupation and emergence.

ACKNOWLEDGMENTS

The problem was suggested to me by Dr. K. K. Nayar, Zoology department, University College, Trivandrum, to whom I am greatly indebted for guidance and help. I am thankful to Prof. K. Bhaskaran Nair and Prof. A. P. Mathew for facilities afforded to me for the work and to Messrs. B. Karunakaran Nair and S. Madhavan Nair for collections of galls from Karakulam and Kaladi respectively.

SUMMARY

1. A detaited tabular account of the emergence of *Schizomyia macarangae* for the season, February-August 1955, from random collections of galls from Trivandrum, Kaladi and Karakulam is given.

Parasites emerged earlier than the midges.

3. Midges began to emerge by June and stopped emergence by the third week of July. Emergence was in the afternoons, and the crest of the wave of emergence was during the 20th of June. Males and females were approximately equal in numbers.

4. The emergence of the adults coincided with the development of foliage in the host plant during the south west monsoon.
5. Wetting does not break the quiescence of larvae in summer months.

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4. Barnes, H. F. 1954. The study of gall midges at Rothamsted., *Marcellia,* 30 Suppl. **15** : 18.
5. Mani, M. S. 1945. Studies on Indian Itonididae VIII., *Indian J. Ent.*, **7** : 183-235.
6. Mani, M. S. 1948. Cecidozoa and Zoocecidia from India, *J. Roy. Asiatic Soc. Bengal.* **14** : 24-195.
7. Nayar, K. K., 1953. *Schizomyia macarangae,* a new species of gall midge., *Proc. Zool. Soc. Bengal.*, **6** : 131-134.
8. Rao, S. N. 1955. Catalogue of the oriental Itondidae., *Agra Uni. J. Res.*, (Science) **4**; 213-282.

June 1955	28-2-1955 A	5-3-1955 B	9-3-1955 C	17-3-1955 D	18-3-1955 E	19-3-1955 F	24-3-1955 G	29-3-1955 H	31-3-1955 I	5-4-1955 J	12-4-1955 K	16-4-1955 L	Male	Female	Total
3-6-1955									1					1	1
4-6-1955									1					1	1
5-6-1955									1					1	1
8-6-1955									3				2	1	3
9-6-1955									9				8	1	9
10-6-1955									3				2	1	3
11-6-1955									4				3	1	4
12-6-1955									4				3	1	4
13-6-1955									3				2	1	3
14-6-1955									6				4	2	6
15-6-1955							4						3	1	4
16-6-1955				21			6						11	16	27
17-6-1955				9			9						7	11	18
18-6-1955				11		9	13				1		7	27	34
19-6-1955				4			4		1				6	3	9
20-6-1955				10		9	24	1					21	23	44
21-6-1955				4			5	1	1				4	7	11
22-6-1955				4		10	2	2	4		1		11	12	23
23-6-1955				3	1	6	5	1	6		1		12	11	23
21-6-1955				2		6	14	3	8				16	17	33
25-6-1955				1	1		4	4					8	2	10
26-6-1955				1		2	3	4	1		1		5	7	12
27-6-1955				1	2	2	6	3					8	6	14
28-6-1955				4	1	2	9	5	1				13	9	22
29-6-1955				2	1	1	3	9					10	16	26
30-6-1955		1		1		2	6	5	2				6	11	17
July 1955															
1-7-1955				2			1	1	2				3	3	6
2-7-1955				3			1	2	2				5	3	8
4-7-1955							1	7	1				6	3	9
6-7-1955								1	1				1	1	2
7-7-1955			5					2	2				4	5	9
8-7-1955				1				2					2	1	3
9-7-1955							1	1			1		1	2	3
10-7-1955			4										1	3	4
11-7-1955			3										...	3	3
12-7-1955		1	1										1	1	2
13-7-1955			1										1	...	1
14-7-1955			1										...	1	1
15-7-1955		1	1						1				1	2	3
16-7-1955			1										...	1	1
17-7-1955													...	...	...
													202	209	411

Table showing the daily emergence of Schizomyia macarangae Nayar from the different collections during the season June-July 1955 the number of each sex of the adult midges is also indicated.

ENTOMOLOGICAL SURVEY OF THE HIMALAYA

PART XVII.—THIRD ANNOTATED CHECK-LIST OF INSECTS FROM THE NORTH-WEST HIMALAYA

By SANTOKH SINGH and V.K. GUPTA, *School of Entomology, St. John's College, Agra.*

This Check-list, forming a supplement to the two lists issued earlier, deals with Orthoptera, Coleoptera, Lepidoptera, Hymenoptera and Diptera. The list includes new entries, addition and corrections to earlier entries.

We thank Prof. M. S. Mani for facilities for work and for guidance.

Order ORTHOPTERA

By SANTOKH SINGH

Family Acrididae

1. *Canophyma mitchelli*, Uvarov, Ent. Mon. Mag. 3(7):268, (1921); JBNHS. 30:552 (1925). *Kashmir.
2. *Chorthippus indus*, Uvarov, "EOS", Revista Espanola de Entomologia, Madrid, 18:98 (1942). *Kashmir:R. Kishan ganga Gurez, 8,900 ft., Gandarbal, 5200 ft., Yusimarg,7500 ft.,Risin gorge, 6000 ft., Perimahal, 5800 ft. Sopor, 5200 ft.; Murree Hills; Ban, Bhuban 6000 ft. [Simla, 5-7000 ft.; U.P., Khurpa tal, Muktesar 7000 ft., N.W. F. P.:Abbotabad Chitral:Izh, Lutkoh Valley, Shahadini, Chimiksan stream, Baluchistan: Nanna Valley, 6000 ft., Chiltan forest, 7000 ft., Urak,7000 ft., Juniper Kotal, 7500 ft.]
3. *Gomphomastax antennatus*, Brunner. in Uvarov, Opuscula Entomologica, Soc. Entom. Lund, 1:18 (1936). *Kashmir: Tragbal pass.
4. *Gomphomastax bolivari*, Uvarov, Opuscula Entomologica, Soc. Entom. Lund, 1:18 (1936). *Kashmir: Tragbal pass, 10,500 ft.
5. *Gomphomastax disparilis*, Bolivar., in Uvarov Opuscula Entomologica, Soc. Entom. Lund, 1:18(1936) *Kashmir: Tragbal pass, 10,500 ft.
6. *Oedaleus senegalensis*, Kr. in Uvarov RIM,. 29(4): 235 ,(1927). *Kashmir: Srinagar, 6000ft., N. W. Himalayas. [Calcutta; Mesopotamia; Trans-caucasia; Persia, Turkestan].
7. *Sphodromerus undulatus pedestris*, Uvarov, Pro. Linn. Soc. London, Session 154, 1941-42, pt. 2, (1943), p. 82.
   Murree Hills: Dhar, 5000 ft. [Chitral: Ramram Gol].

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The Second Check-List in this series was published in *Agra Univ. J. Res.*, 4 (Science) : 657-716, December 1955.

8 *Spathosternum prasiniferum*, (Walker), in Uvarov, Opuscula Entomologica, Soc. Entom. Lund, 1:18 (1936)*Kashmir,Tragbal, 10,500 ft.

Family Tettigonidae

9. *Ducetia japonica*, (Thunberg), in Uvarov, OpusculaEntomologica Soc. Entom. Lund, 1:18 (1936).
Srinagar.

10. *Metrioptera kashmira*, Uvarov, Opuscula Entomologica Soc. Entom. Lund, 1:18 (1936).
*Srinagar

11. *Metrioptera* sp, Uvarov, Opuscula Entomologica, Soc Entom, Lund, 1:18 (1936).
*Kashmir: Tragbal, 10,5000 ft.

12. *Plicigera himalayana*, Uvarov, J.B.N.H. S., 29:652 (1923-24). *Dalhousie.

13. *Hyphinomos fasciata*, Uvarov, JBNHS., 28:71-75, (1921). *Dakar, Western Tibet, 15000-16000 ft.

Order COLEOPTERA

By SANTOKH SINGH

Family Cicindelidae

1. *Cicindela aurulenta*, Fabricius, Syst. El., 1:239, (1801); FBI., Coleop., Cicindelidae, p:383, (1912). *Kulu. [Nepal; Sikkim; Bengal; Burma; Bihar; Chhota Nagpur; Ceylon; Karen Hills; Malaya Peninsula; Sumatra; Java; Borneo; Combodia; Siam; S. China; Formosa; China; Hongkong; Macao.]

2. *Cicindela granulata stoliczkana*, Bates, PZS., P. 713, (1878); FBI., Coleop., Cicindelidae, p. 439, (1912).
*N. W. Kashmir; Jhelum Valley. [E. Turkestan; Kuen Lun; Tarbagatai Mts].

3. *Cicindela sumatrensis*, Herbst., Käfer, 10:179, (1806) FBI., Coleop., Cicindelidae, p. 371, (1922). *Kashmir. [Ceylon; Madras; Bombay; Sind; Bengal; Nepal; Burma; Malaya Peninsula; Sumatra; Borneo; Philippine Islands; Hainan; China; Formosa; Japan; Yunan].

4. *Cicindela venosa*, Kollar, Ann. Hafmus. Wien., p.331, (1836)
*Kashmir. [Bengal; Bhutan; Bombay; Bihar; Orissa; Darjeeling; Karachi; Kurseong; Pegu; Pondicherry; Sara Ghat; Cambodia; Pak-lay; Lao-Kay].

5. *Neocollyris attenuata*, Redt., Hugel's Kaschmir, 4:498, (1848) FBI., Coleop., Cicindelidae, p.240, (1912).
*Kashmir; Kangra Valley. [Simla; Soom, 4-5000 ft.; Bhimtal (Kumaon) Nepal; Sikkim; Assam; Khasi Hills; Calcutta; N. Manipur; Mungphu].

Family Dytiscidae

6. *Bidessus geminus*, F., RIM., 37(3):374, (1935).
*Kashmir. [Simla Hills].

7. *Coelambus parallelogrammus*, Ahr., RIM., 37(3):368, (1935).
*Kashmir: Chinar Bagh nullah.

8. *Laccophilus minutus*, L., RIM., 37(3):374(1935).
*Kashmir: Nasratabad.

9. *Platambus fletcheri*, Zim., RIM., 37(3):370, (1935), *Murree; Dhobi Ghat. [Assam:Khasi Hills, Shillong; Kumaon: Malwa Tal, 3600 ft.]

Family Gyrinidae

10. *Gyrinus distinctus*, Aube. Icon., 5:383, pl. 43, f.3, (1836-38); Cat. Indain Ins., 19:7, (1930).
*Kashmir: Chinar Bagh nullah. [Europe; Egypt).

11. *Protodineutus indicus*, (Aube)., Spec, col., 6:772, (1838) (*Dineutes*); Cat. Indian Ins., 19:13, (1930).
*Kashmir: Jhelum Valley; Kangra.
[Simla Hills; Dehra Dun; Massourie; Sikkim; Assam; Patiala State; Baluchistan; Bombay; Poona; Kanara; Coorg; Bengalore; Coimbatore; Nilgiris; Rewa state;S. Malabar; Travancore; Ceylone; Madras, Orissa; Chhota Nagpur; Bihar; Bengal].

Family Hydrophilidae

12. *Atractelophorus frater*, A. d,Orchymont, Ann.et. Bull. Soc. Ent. Belgique, 66·93, (1926).
*Kashmir; Rupshu: Tso Morari. [Laptel (Kumaon-Tibet frontier].

13. *Hydrous cashmirensis*, (Redt.), Hügel's Kaschmir, 4(2):513, (1844) (*Hydrophilus*) Cat. Indian Ins. 14:126,(1928).
*Kashmir. [Burma; Ceylone; Indo China; Cambodia; Annam; China; Japan; Sumatra.]

14. *Hydrous pallidipalpis*, M'Leay, Annul. Jav., p.35, (18)25.
*Kashmir. [India; Tibet; Burma; China; Japan; Formosa Sumatra; Java].

15. *Hydrous piceus*, (Linn.), Syst. Nat. ed. 10:411, (1758) (*Dytiscus*).
*Palaearctic Kashmir.

16. *Stenolophus rufipes*, Fab., Ent. Syst., 1:183, (1792).
*Kashmir. [Oriental India; Ceylon; China; Indo China; Sumatra; Java; Formosa; Japan; Phillippine].

Family Staphylinidae

17. *Atheta* (*Bessobia*) *submetallica*, Cam. Mem. Connect. Acad., 10:20, (1934); FBI, Coleop., Staph., 4(1): 313, (1939).
*Indian Tibet: Tsak-Shang, 15, 985 ft.

18. *Atheta* (*Microdota*) *ladakiana*, Cam., Mem. Conne ct. Acad. Arts and Sci., 10: 20, (1934); FBI, Coleop. Staph., 4 (1): 331, (1939).
*Indian Tibet : Tsak-Shang, above Tso-Morari, 15,985 ft.

Family Lycidae

19. *Calochromus costulatus*, Kln., IFR., 13 (6): 260, pl. iv, f. 120-122, (1929.)
*Kashmir. [Assam].

20. *Calochromus kaschmirensis*, Kln., IFR., 13 (6): 259, (1929).
*Kashmir.

21. *Lycostomus acustecostatus*, Fairm., Bull. Comptes rendus des Sciences de la Societe Entom. Belgique, p: 89, (1891).
*Kashmir.

22. *Lycostomus orientalis*, Kln., Stettiner ent. Z., 91: 94, (1930).
*Kashmir. [Mussoorie].

23. *Lycostomus praeustus*, (Fabr.), Ent. Syst., p: 107, (1792) (*Lucus*).
*Kashmir. [Kumaon; Assam; Nagpur; Belgaum; Madras; Ceylon; Burma; Cambodia; Laos].

24. *Lycostomus purpureiventris*, Gorh., Ann. Soc. Ent. Belgique, 39: 299, (1895).
*Chamba.

25. *Lycostomus similis*, Hope, Gray's Zool. Miscell., p. 26, (1879).
*Kashmir. [Dehra Dun; Kumaon; Allahabad; Nepal; Bhutan; Assam; Sylhat; Darjeeling; Coimbatore; Ceylon; Siam; Tonkin; Laos; China].

Family Nitidulidae

26. *Cyllodes indicus*, Grouv., Ann. Soc. ent. Belgique, 38:462, (1908).
*Kashmir. [Burma; Bengal; Kanara; Nilgiris].

27. *Epuraea waterhousei*, Grouv., Ann. Soc. ent. Belgique, 38: 34 (1908).
*N. W. Himalayas.

Family Coccinellidae

28. Coccinella 7-punctata Linn. Throughout North-West Himalaya. upto 14,000 ft. [India and Europe].

29. *Thea bisoctonata*, *Dhauladhar, 14,000 ft. [Indian Plains].

30. *Epilachna* Sp. *Dharamsala.
Kulu. [India].

30.a *Brumus suturalis*. *Dharamsala.
Kulu. [India].

Family Meloidae

31. *Mylabris phalerata*. *Lakka Pass 12,000 ft. Kangra-Dharamsala. Dalhousie. [Throughout India].

Family Scarabaeidae

32. *Liatongus phanaeoides*, Westw., Royle's Himalaya, Entom., p. 55 pl. 9, f. 3, (1840); FBI, Lamalli., 4 : 364, (1931).
*Gharial, Murree Subdivision, 6000 ft.

Mussoorie, 6000-7000 ft. [Bengal; Burma; Indo China; South China; Japan].

33. *Onitis crassus*, Sharp, Col. Hefte. 14 48, (1775); FBI, Lamelli., 3 : 400, (1931).

*Thobba, Murree Hills. [U. P.; Suswa R.; C. P.) Basha Ghat, Bergi].

34. *Sacarabaeus sacer*, L., Syst. Nat. ed., 10: 347, (1758); FBI.; Lamelli., 3 : 40, (1931).

*North Kashmir: Hunza, 8000 ft.; Thobba Hills, Murree Hills.

Family Rutelidae

35. *Anomala stoliczkae*, Sharp, J. R. Asiatic Soc. Bombay, 47 (2) : 173, (1873); FBI, Lamelli., 2 : 243, (1917).

*Murree. [U. P. : Jaunsar; Sikkim; Darjeeling; Tibet; W. China].

36. *Mimela passerinii*, Hope, Proc. Linn. Soc., 1 : 128, (1942); FBI, Lamelli., 2 : 105, (1917).

*Kashmir. [Sikkim: Darjeeling, Mungphu, Jallapahar 7500 ft., Lachen Valley, 7000 ft; Tibet: W. China].

37. *Popillia clypealis*, Ohaus., Stett. Ent. Zeit., p. 347, (1897); FBI, Lamelli., 2 : 71, (1917).

*Kashmir. [Simla Hills; Khasi Hills].

Family Cetonidae

38. *Protactia hieroglyphica*, (Menetr.), Cat. raisonne, p: 189, (1832) (*Cetonia*); FBI, Lamelli., 1 : 159; (1910).

*Murree. [Dehra Ghazi Khan; Turkestan ; Caspian sea].

Family Curculionidae

39. *Leptomias bimaculatus*, Fst., Stettin. Ent. Zeit., p: 132, (1896); FBI., Coleop., Curculio., 1: 188, (1916).

*Murree.

40. *Leptomias jekli*, Fst., Stettin. Ent. Zeit., p. 135, (1896); FBI, Coleop., Curculio., 1 : 181, (1916).

*Murree.

41. *Leptomias sulcicollis*, Marsh., FBI., Coleop., Curculio., 1 : 187, (1916).

*Murree. U. P: Bhim tal, 4500 ft., Kumaon.

42. *Leptomias verrucicollis*, Fst., Stettin. Ent. Zeit., p: 138, (1886); FBI, Coleop., Curculio., 1:183, (1916).

*Murree.

Family Carabidae

43. *Abacetus haplosternus*, Chaud., Bull. Mosc., 2: 25 (1887).
*Katrain. [Almora; Ranikhet; Haldwani; Nagpur; Siam; Sumatra].

44. *Acinopus laevigatus*, Men., Cat. rais., p. 128 (1832).
*Kashmir: Sind Valley, Sonemarg, Srinagar.

45. *Acupalpus annamensis*, Bates, Ann. Soc. ent. France, p. 272 (1889).
*Kulu. [Almora; Ranikhet; C. P; Tumgaon, Korai; Madras; Kodaikanal; Ceylon: Weligama, Anuradhapur; Bhambo; Tenasserim; Java; Sumatra; Cochin-China; Annam; Tonkin; Formosa; Hongkong; Philippine Ils].

46. *Amara ambigena*, Bates, PZS., p. 716 (1878).
*Kashmir: Pangong Valley between Tanktze andChagra.

47. *Amara apricaria*, (Payk.), Mon. Carab., p. 125 (1790), (*Carabus*).
*Kashmir: Sind Valley, Dras, Kargil, Leh, Sonemarg. [Canada; Pamir].

48. *Amara batesi*, Csiki., Col. Cat. 104 Carab., p. 454, (1929).
*Himalayas: Kashmir. [Kashmir to Sikkim].

49. *Amara darjelingensis*, Putz., Stettin. Ent. Zeit., p. 102 (1877).
*Punjab: Seraj (Jalori Pass) Dharmsala, Naggar, Parbati valley.
[Kumaon: Sunderdhunga Valley, Sukha tal, Gori valley and Gorge, Bhurphu, Chulli Khud (Chakrata); Sikkim: Darjeeling, Lachung, Khasi Hills.]

50. *Amara himalaica*, (Bates), PZS., p. 716 (1878), (*Leiocnemis*)
*Kashmir: Dras, Kargil, Leh, Sonemarg; Lahoul: Sumdeo. [Bashahr: Poo; Simla Hills: Kotgarh, Matiana; Almora; Ranikhet].

51. *Amolops depilatus*, (Bates), PZS., p. 214 (1889), (*Molops*).
*Kashmir: Goorais valley, Skardo.

52. *Amolops piliferus*, (Bates), PZS., p. 718 (1878), (*Molops*).
*Kashmir: Goorais valley Skardo, Murree.

53. *Anchomenus incisus*, Andr., Eos., 3 : 77 (1927).
*Kashmir: Sintan.

54. *Anchomenus mesostictus*, Bates, PZS., p. 215 (1889).
*Kashmir: Goorais valley.

55. *Anchomenus ustus*, Andr., Eos., 3 : 75 (1927).
*Kashmir: Kishtwar, Panjal, Lidar valley.

56. *Anchomenus ustus belli*, Andr., Eos., 3 : 77 (1927).
*Kashmir.

57. *Anthia sexguttata orientalis*, (Hope), Col. Mon. 2 : 163 (1838,) (*Pachymorpha*).
*Himalayas: Jhelum valley. [Poona, Bangalore].

58. *Apristus aeneomicans*, Chaud., Bull. Mosc., p. 66 (1850).

*Punjab: Seraj, Jibhi . [U. P: Almora; Swal R. basin, Ranikhet, Dehra Dun, Kali Gad, Kosi River, Haldwani, Arni Gad (Mussoorie), Binal Gad (Chakrata); Sikkim: Gopaldhara, Birik, Tistavalley; E. Duras].

59. *Asaphidion substriatum*, Andr., Ent. Month. Mag., p. 56 (1925); FBI, Coleop., Carab., 2 : 89 (1935).

*Punjab : Seraj. [Almora].

60. *Bembidion beesoni*, Andr., FBI, Coleop. Carab., 2: 109 (1935).

*Kashmir : Kilanmarg, 11,000 ft. Razhdhainangan 12,000 ft.

61. *Bembidion dardum*, Bates, PZS., p. 212 (1889).

*Kashmir: Goorais valley, Skardo. [Bokhara].

62. *Bembidion discordans*, Net., FBI., Coleop. Carab., 2 : 101 (1935).

*Kashmir: Shigar, 7000 ft.

63. *Bembidion trimaculatum*, Andr., Eos., 3: 68 (1927); FBI, Coleop. Carab., 2 : 202 (1935).

*Punjab: Upper Jhelum, Daphar plantation. [Layallpur Dehra Dun].

64. *Brachinus pallidipes*, Reitt., Ent. Blatt., p. 137 (1919).

*Kashmir: Goorais valley; Kangra. [Bashahr: Poo; Dehra Dun; Almora; R. Sarda Gorge; Tanak pur].

65. *Brachinus suturellus*, Chaud., Mont 69.

*Nurpur (Kangra). Almora; Lucknow; Chota Nagpur; Mhow; Bhowali; Belgaum; Bangalore; Tharrawaddy; Rangoon].

66. *Callistomimus chalcocephalus*, (Wield.), Zool. Mag., 2 (1): 57 (1823), (*Panagaeus*).

*Jhelum valley; Kangra: Baijanath. [Sarju and East Ramganga valleys; Almora; Haldwani; Dehra Dun; Sikkim: Gopaldhara; Nilgiri Hills; Maymyo; Java; Karakatan; China].

67. *Chlaenius anchomenoides*, Bates, PZS., 212 (1889).

*Kashmir: Goorais valley.

68. *Chlaenius atripes*, Chaud., Mon. 160.

*Kashmir. [Assam; Dacca; Calcutta; Rangoon].

69. *Chalaenius fugax*, Chaud., Mon. 266.

*Nurpur (Kangra). [Chota Nagpur, Konbir, Tetara, Ranchi, Singhbum; Nagpur: Seoni, Raipur, Chanda; Belgaum; Poona; Kanara; Surada; Madras; Horseby-konda; Malbar; Bangalore; Rangoon River].

70. *Clivinia tenuelimbatus*, Ball., Bull. Mosc., 2 : 326 (1870).
*Kashmir: Goorais valley; Leh. [Turkestan].

71. *Clivinia velocipes*, Chaud., Mon. 266 (part);AMNH.,17(5):74 (1886).
*Kangra. [U. P.: Someswar, Nainital, Almora, Bhimtal, Haldwani C. P. : Mangli; Nagpur, Belgaum; Kasara; Nilgiri Hills; Kodakanal; Ceylon: Dikoya; Manipur].

72. *Coleolissus perlucenus*, (Bates), PZS., 715 (1878) (*Hypolithus*).
*Jhelum valley.

73. *Colpodes eulabes*, Bates, PZS., 215 (1889).
*Kashmir: Goorais valley.

74. *Colpodes melittus*, Bates, PZS., 215 (1889).
*Kashmir: Goorais valley.

75. *Colpodes ovaliceps*, Bates, PZS., 719 (1878).
Kashmir: Pirpanjal, Murree.

76. *Cymindoidea qnadrimaculata*, (Redt)., Hugel's Kaschmir, 4(2): 499 (1844), (*Cymindis*).
*Kashmir.

77. *Diplocheila latifrons*, (Dej.), Sp. Gen. Col., 5 : 679 (1831).
*Kashmir. [Calcutta; Birbhum; Murshidabad; Rajmahal; Bangalore; Palon; Siam; Indo-China; Java; Chusan; Japan].

78. *Dyschirius ladakensis*, Andr., FBI., Coleop. Carab., 1 : 410 (1929).
*Ladak.

79. *Dromias adoxux*, Andr., AMNH., 12 (9): 687 (1923).
*Dharmsala. [Simla Hills; Kotgarh; Layallpur; Kumaon: Almora, Nainital, Ranikhet, Bhatkot, Dudhatoli; Chakrata; Sikkim: Kurseong, Gopaldhara].

80. *Euleoptus ooeerus*, Chaud., Bull. Mosc., 1 : 365 (1850).
*Kangra valley. [Simla Hills: Theog, Matiana, Fagu Lansdowne; Dehra Dun; Mussoorie; Kumaon: Almora, Upper Gumti valley, Gori valley,East Ramganga valley.]

81. *Harpalus anxius*, Dufts., Faun Austr., 2 : 101 (1812).
*Kashmir: Goorais valley, Sonemarg, Pirpanjal; Chamba Kangra; Mandi; Naggar; Lahoul: Cimur, Keyling, Sumdeo, Sisu. [Jhelum; Kalka; Bashahr: Poo, Nichar.]

82. *Harpals indicoula*, Bates, PZS., 714 (1878).
*Murree and N.W. Himalayas. [Murree to Darjelling; Chota Nagpur: Konbir].

83. *Harpalus kashmirensis*, Bates, PZS., 213 (1889).
*Kashmir: Goorais valley, Pirpanjal.

84. *Metabletus cymindulus*, Bates, Ann. Mus. Civ. Nat. Genova, 32:418 (1892).

*Bajaura. [U. P. : Almora, Dudhatoli, Tanakpur, Dehra Dun; Sikkim: Gopaldhara, Darjeeling, Kurseong; Shillong; Calcutta; Pusa; Lebong; Karen Hills; Katha; Yunnan].

85. *Nebria xanthacra*, Chaud., Bull. Mosc., 1 : 423 (1850); FBI, Coleop. Carab., 1 : 122 (1929).
*Kashmir: Ramsu. [Simla Hills: Matiana; Bahshahr; Sangla; Dehra Dun; Bhowali; Nainital; Ranikhet; Almora].

86. *Omophron bicolor*, Andhr., AMNH., 4 (9): 292 (1919); FBI, Coleop. Carab., 1 : 159 (1929).
*Kangra. [Calcutta; Dacca].

87. *Ophonus indicus*, (Bates), Comp. Soc. Ent. Belgique, 332 (1891), (*Harpalus*).
*Kashmir to Bhutan. [Throughout the Himalayan tract from Kashmir to Bhutan].

88. *Ophonus tridens*, (Moraw.), Mel. Biol. Acad. Sci. Petr., 4 · 245 (1862), (*Harpalus*).
*Kulu. [Indo-China; Yunnan; China Japan; Korea].

89. *Orthogonius mniszechi*, Chaud., Mon. 101.
*Kulu. [Malaya Peninsula : Lang Kawi; Borneo].

90. *Pheropsophus consularis*, (Schm. Goeb.), Faun. Col. Birmainae, 75 (1846).
*Spiti Gharry; Kangra. [Dehra Dun; Ranikhet Chota Nagpur: Yetars, Konbir; Chapra; Sardah; Dacca; Assam; Silonibari, Sibsagar, Siliguri, Rotung; Surada; Karen Hills; Bhamo].

91. *Pristonychus kashmirensis*, Bates, PZS., 214 (1889).
*Kashmir: Goorais valley, Liddar valley, Killanmarg, Gulmarg, Sintan, Pirpanjal, Upper Munda; Kulu. [Simla].

92. *Pristonychus spinifer*, Schauf., Sitzungsb. Ges. Isis., 66 (1862).
*Himalayas; Dharmsala. [Campbellpur].

93. *Pterostichus sintanus*, Andr., Eos., 3 : 174 (1927). *Kashmir.

94. *Rhapalopalpus janthinus*, Redt., Hugel's Kashmir, 4(2) : 500 (1844).
*Kulu; Kashmir. [Grudaspur; Rawalpindi; Siwaliks; Ramnagar (U. P.); Kheri; Dehra Dun; Haldwani; Gorakh pur].

95. *Scarites punctum*, Wied., Zool. Mag. 2 : 38 (1823); FBI, 1 : 272 (1929).
*Kulu; Akalgarh. [Mothronwala; Dehra Dun; Boxar (Nainital); Tanakpur; Almora; Hardwar; Roorkee; Pusa; Chapra; Malda; Patkai Hills; Assam; Nepal].

96. *Stenolophus discophorus*, Fisch., Ent. Russ., 2: 141 (1824).
*Srinagar. [Mesopotamia; Arabia; Siberia; Turkestan; Transcaspia; Southern Europe].

97. *Stephana princeps*, (Chaud)., Bull. Mosc., 1 : 42 (1852) (*Lebia*).
*Deota (N. W. Himalayas). [Thadyar (Jaunsar Himalayas) Kumaon; Kurseong; Maflong (Khai Hills)].

98. *Tachys vilis*, Andr., Ann. Mus. Civ. Nat. Genova, 51 : 327 (1925 FBI, 2 : 221 (1935).
*Kashmir.

99. *Trechus indicus macroderus*, Jeann., AMNH., 1(10): 290 (1928).
*Kishtawar.

Additional Notes

Family Carabidae

1. *Amara aenea* (Geer), Mem. Ins., 4 : 98 (1774) (*Carabus*); Contribution No. 62, 478 (1955).
*Palaerctic region; Kashmir: Sind valley, Sonemarg, Gulmarg, between Gilgit & Nagy; Bajaura.

2. *Amara bambidunyae* Bates, PZS, p. 716 (1878) ; Contribution No. 62, 478 (1955).
*Kashmir: Goorias Valley; Kulu: Koty; Spiti: Pulga.

3. *Amara nila* Andr., Mission Babault, p. 97 (1924);
*Chamba; Kangra; Kulu; Kandi; Koty; Spiti: Mnikaran, Tchary-Djoni, Pulga, Tsho-ti.

4. *Anchomenus caesitius* Andr., Mission Babault, p. 104 (1924); Contribution No. 62, 478 (1955).
*Lahoul: Sissu, Sumdeo; Kulu: Kandi, Koty. [Sunderdhunga Valley, Gori Valley and Gorge, Burphu (Almora)]

5. *Anchomenus eurous* Andr., Mission Babault, carab., p. 105 (1924); Contribution No. 62: 478 (1955).
*Spiti : Pulga; Kulu : Kandi, Koti, Manali. [Dehra Dun, Mundali, Bagar Kote, Nainital, Almora, Kali Valley, Sunder dhunga Valley, Gori Valley & George.]

6. *Anchomenus ladakensis* Bates, PZS, p. 718 (1878) Contribution No. 62, 478 (1955).
*Kashmir : Leh, Kargil Pangong Valley between Tangtize & Chagra. [Tibet: Gyangtse; Pamir.]

7. *Axonya championi* Andr., AMNH, 12 (9): 680 (1925); Contribution No. 62, 478 (1955).
*Kangra[Nalagarh; Almora; Haldwani; Kathgodam; Bijnor; Nainital; Dehra Dun; Lucknow; Sikkim; Birik; Tista Valley; Namsoo; Assam between Pasi Ghat and Kobo; Dihong river, Mangaldai].

8. *Brachinus stevensi* Andr., Mission Babault, p. 107 (1924); Contribution No. 62, 482 (1955).
   *Kangra. [Assam: Kobo, Dihong R. below Pasighat; Sikkim: Tista Valley; Kalimpong; Garhwal; Dhikala; U. P. : R. Sarda Gorge, Ranikhet, Dehra Dun].
9. *Calathus himalayae* Bates, Entom, Suppl., 9 (1891); Contribution No. 62, 482 (1955).
   *Kulu: Koty, Rotang Valley. [Gori River Gorge; Kali Valley and Dhauli Ganga (Almora)].
10. *Callistomimus coarctatus* (Lef.), Ann. Soc. Ent. France 230 (1851) (*Callistus*); Contribution No. 62, 483 (1955).
    *Kulu: Manali; Spiti: Manikarn. [Almora; Ranikhet; Upper Gumti Valley; Sarju Valley; Khairna; Malwa tal, Siwalik Hills; Kanarichina; Eastern Duras; Sikkim: Gopaldhara, Namsoo; Darjiling; Pashok; Mungpher; Kurseong].
11. *Carabus barysomus* Bates, PZS, 210 (1889); Contributoin No. 62: 483 (1955).
    *Kashmir : Goorias Valley; Batote, Pir Panjal. [Hazara: Lower Kagan Valley; Agra].
12. *Chlaenius agilis* Chaud, Bull. Mosc., 3 : 246 (1850); Contribution No. 62, 485 (1955).
    *Kangra: Naggar. [Almora; Ranikhet; Kathgodam; Nainital; Siwaliks; Dehra Dun; River Song; Nim Nadi; Lucknow; Bashahr: Poo Darjiling: E. Duras; Assam; Indochina].
13. *Chlaenius caeruleus* (Stev), Mem. Soc. Nat. Moscow, 2 : 38 (1809) (*Carabus*); Contribution No. 62, 485 (1955).
    *Kashmir: Goorais Valley; Ladakh; Punjab: Seraj. [Baluchistan; Nushki; Armenia; Southern Asia.]
14. *Chlaenius pictus* Chaud, Bull. Moscow, 3 : 208 (1856);
    *Kangra. [Khasi Hills; Sibsagar; Calcutta; Saran; Birbhum; Pusa; Chapra; Tatara; Mhow; Bombay; Deolah; Kathiawar; Saran; Madura; Coimbatore; Bhamo; Java; Sumatra; Siam; Indo-China; China]
15. *Chydaeus bedeli* (Tchitch) L'Abeille, 29: 66 (1897) (*Acrogenioden*); Contribution No. 62, 485 (1955).
    *Spiti: Pulga; Kulu: Kandi, Koty. [Gori River Gorge; Sunderdhunga; Pindar Valley (Almora); Sikkim; Darjilling; Gopaldhara; Lachung; China Mungphu.]
16. *Craspedonotus himalayanus* Sem., Rev. Rus.Ent., 216 (1825); Contribution No. 62, 485 (1955)

*Kangra; Kulu: Parbati Valley. [Punjab: Baddia; Dehra Dun].

17. *Cyclosomus suturalis* (Wield.), Zool. Mag., 1 (3): 169 (1819) (*Scolytus*) Contribution No. 62, 485 (1955).
*Kulu. [Dehi; Malda; Sikkim: Gopaldhara; Gauhati; Sumatra; Laos; Annam].

18. *Harpalus melaneus* Bates, PZS, 714 (1878); Contribution No. 62, 486 (1955).
*Kashmir: Sind Valley; Leh; Gond; Baltal; Sonemarg; Lidder; Kazi; Nag range; Goorias Valley; Skardo; Yusimarg; Gulmarg; Pir Panjal; Kishtwar,Uri;Chamba; Muree; Dalhouseie; Spiti; Pulga; Lahoul: Zingzingbar; Sumdeo; Patseo; Sisu; Keyling; Gondla; Cimur; Kulu: Koty; Rotang Valley. [Bashahr: Chini; Taranda; Simla Hills; Phagu, Baghi, Kufri; Narkanda; Mundali (Dehra Dun); Burphu & Milam (Almora)].

19. *Harpalus quadricollis* Redt., Hugel's Kaschm., 4 (2): 502 (1844); Contribution No. 62, 486 (1955) .
*Kashmir: Goorias Valley; Skardo; Sonemarg; Baltal; Lahoul: Sisu; Zingbar; Patseo; Sumdeo; Keyling. Spiti: Pulga. [Rawalpindi; Bashahr: Poo; Kumaon: Sunderdhunga; Kali Valley; Ranikhet].

20. *Hypsinephus ellipticus* Bates, PZS, 716 (1878); Contribution No. 62, 486 (1955).
*Kashmir: Baltal; Pangong Valley. [Tibet: Supi River].

21. *Mastax annulata* Andr., Mission Babault, 3 (1924); Contribution No. 62: 486 (1955).
*Spiti: Manikarn; Sutlej Valley near Simla. [Almora, Sarju Valley; Malwa Tal, Khairna: Haldwani; Lansdowne; Someswer].

22. *Mastax vegela* Andr., Mission Babault, 110 (1924); Contribution No. 62, 486 (1955).
*Kangra. [U. P. Almora, Nainital, Phanduwala; Khairna; Tanakpur; Haldwani; R. Sarda Gorge; Eastern Duars; Sikkim: Great Rangit Valley; Tista Bridge; Brik].

23. *Metabletus fuscomaculatus* (Motch)., Ins. Sib., 59 (1844); Contribution No. 62, 486 (1955).
*Pir Panjal (Kashmir) Jalori Pass; Seraj; Mandi; Dharmsala; Chamba. [Punjab: Nalagarh, Baddia; Fagu; Theog; Matiana; Almora; Nainital; Seistan; Persia, South Russia; Asia minor; North Africa; Madera].

24. *Omophron axillaris* Chaud, Mon. 59; Contribution No. 62, 487 (1955).

    *Bajaura. [Kotkhai (Simla); Haldwani; Almora; Swal R. basin; Sarju Valley (Kumaon); Bengal].

25. *Pheropsophus catoirei* (Dej), Sp. gen. Col., 1: 301 (1825); Contribution No. 62, 488 (1955).

    *Kashmir [Throughout India westward to Kashmir, Sind, Khyha Pass; Ceylon: Hambamtota; Kalupalvani; Murunkan; Burma; Andamans Ills].

26. *Pristonychus kashmirensis babulti* Andr., Mission Babault, 100 (1924)

    *Murree; Kashmir: Sonemarg, Nagaberan; Spiti: Tsho-ti, Tchary-Djoni, Pulga; Lahoul: Sisu, Keyling, Sumdeo; Gondla; Kulu: Kandi, Koti, Rhotang Valley. [Narkanda].

27. *Sphodrus indus* Chaud., Bull. Moscou, 1 : 67 (1852); Contribution No. 62; 488 (1955).

    *Chamba; Murree. [Baddia (Punjab); Kasauli; Kailana; Dehra Dun]

28. *Stenolophus bajaura* Andr., Mission Babault, 95 (1924); Contribution No. 62, 488. (1955).

    *Kashmir, Kangra; Bajaura; Spiti : Manikaran. [Kumaon: Sarju Valley; Pusa; Fyzabad].

29. *Tetragonderus arcuatus* Dej., Sp. gen. Col. 4: 495 (1895); Contribution No. 62, 489 (1955).

    *Kangra: Bajaura. [Shillong; Chandpur (Assam;). Sikkim: Kurseong, Gopaldhara; Baska-Daur; Dacca; Calcutta; Sardah; Murshidabad; Pusa; Chapra; Bhogaon (Purnea) Sitamarhi; Muzaffarpur; Samestipur; Chota Nagpur; Konbir; Dehra Dun; Almora; Haldwani; Lyallpur; Mandla; Chikalda; Bombay: Pondicherry; Karen Hills; Mandalay; Bhamo; Toungoo; Rangoon; Palon; Laos; Egypt; Sudan; Mesopotamia].

30. *Trechus indicus championi* Jeann., AMNH, 5(9):109 (1920): Contribution No. 62, 9 (1955)

    *Spiti:Pulga; Lahoul: Chimur; Dharmsala; Mandi; Kashmir ; Baltal Sonemarg. [Simla Hills : Kotgarh, Gahan; Almora Upper Gumti Valley; Sunderdhunga Valley; Swal R. basin; Nainital; Chakrata; Ranikhet; Sikkim; Gopaldhara; Darjiling].

Order LEPIDOPTERA

By SANTOKH SINGH

Family Papilionidae

1. *Papilio arcturus*, Westwood, AMNH., 9:37 (1842); Bingham, FBI., 2:87 (1907).
   *Murree. [Murree to Sikkim; Bhutan; Assam; Burma; Tenasserim].
2. *Papilio kashmirensis*, Rothschild, Nov. Zool., 2:407 (1895); Bingham, FBI., 2:95 (1907).
   *Kashmir. [Kashmir to Mussoorie].
3. *Parnassius acco pundjabensis*, O. Bang-Hass., Horae Macrolepidopteroligicae, 1:23 (1927); Talbot, FBI., 1:296 (1939).
   *East Spiti: Tum-Tum-Thang Mts. 15,000 ft.
4. *Parnassius actius yelyangi*, O. Bang-Hass, Ent. Zeit,. 48:135 (1934); Talbot, FBI., 1:263 (1939).
   *South Kashmir; Zanskar; Yelyang Pass, 13,500 ft.
5. *Parnassius delphius atkinsoni*, Moore, Lep, Ind., 5:121 (1901-1903); Bingham, FBI., 2:125 (1907).
   *Pir Panjal Range, North Kashmir.
6. *Parnassius delphius stenosemus*, Honrath., Ent. Nachricht., 16:127 (1890); Bingham, FBI., 2:125 (1907).
   *Ladakh: Kutie Pass, 17,000 ft.
7. *Parnassius delphius stoliczkanus*, Felder, Novara Reise, Lep., 2:138 (1865); Bingham, FBI., 2:123 (1907).
   *Ladakh; Bara Lacha Pass, 18,000 ft., ; Runang and Hungrung Pass at 15,000 ft.
8. *Parnassius epaphus cachemiriensis*, Oberthür., Et d'Ent., 14:1-18 (1891); Talbot, FBI., 1:266 (1939).
   *Sutlej valley ; Parbati valley ; Manali; Hamta; N. W. Himalayas. [Chitral to Kumaon].
9. *Parnassius simo simo*, Gray, Talbot, FBI., 1:288 (1939).
   *Sutlej valley; Parbati valley; Manali; Hamta. [Nepal to Tibet].
10. *Polydorus philoxenus philoxenus*, (Gray.). Zool. Misc. 1:32 (1831); Talbot, FBI., 1:96 (1939). *Kashmir. [Kashmir to Nepal].
11. *Polydorus philoxenus punchi*, (O. Bang-Hass.) Ent. Zeit., 46:261 (1833) (*Papilio*); Talbot, FBI., 1:97 (1939).
    *W. Kashmir: Jhelum River, 11,000 ft.

Family Pieridae

12. *Anaphes aurota aurota*, (Fabr.) Ent. Syst., 3 (1):197 (1793) (*Papilio*); . Talbot, FBI., 1:380 (1939,.

*N. W. Himalayas: Sutlej valley. [All India Except Assam, Burma; subspecies extend to Palestine and Africa; a stragglar from Great Nicobars].

13. *Catopsilia florella*, (Fbr.), Syst. Ent., 479 (1775) (*Papilio*); Bingham, FBI., 2:223 (1907).

*Dharmsala. [Sikkim; Bengal; Nilgiris; Western India; Mysore; Assam; Burma; Ceylon; Punjab; Karachi; Persia; Aden; Afghanistan; Africa; China; Siam]

14. *Cepora nerissa nerissa*, (Fabr.), Syst. Ent., 417 (1775) (*Papilio*); Talbot, FBI., 1:364 (1939).

*Sutlej valley. [Sikkim to Assam].

15. *Colias croceus fieldi*, Men., Cat, Mus. Ptr., Lep., 1:79 (1855); Bingham, FBI., 2:243 (1907).

*N. W. Himalayas, 2,500-14,000 ft. [Chitral to Sikkim; Bhutan,25,00-14,000 ft.; Assam; Upper Burma; China].

16. *Colias shyale*, (Linn.), Syst. Nat., 10:469 (1758) (*Papilio*); Bingham, FBI., 2:234 (1907).

*Kashmir; Kulu. [Chitral to Bhutan;Baluchistan; widesspread in Palaearctic].

17. *Colotis etrida*, (Boisduval), Sp. Gen. Lep., 1:576 (1836) (*Anthocharis*); Bingham, FBI., 2:270 (1907).

*Kashmir. [Baluchistan; Outer Ranges of Himalayas; throughout peninsular India except Bengal].

18. *Delias belladona*, (Fbr.)., Ent. Syst., 3:180 (1793) (*Papilio*): Bingham FBI., 2:148 (1907).

*N. W. Himalayas: Kulu. [Kulu to Sikkim; Bhutan; Assam; Khasi Hills; Burma; Tenasserim; Siam; China].

19. *Gonepteryx rhamni*, (Linn.), Syst. Nat., 10:470 (1758) (*Papilio*); Bingham, FBI., 2:129 (1907).

*N. W. Himalayas. [Chitral to Darjeeling; Upper Burma; Shan States].

20. *Gonepteryx zaneka*, Moore, PZS., 493 (1865); Bingham, FBI, 2:230 (1907).

*N. W. Himalayas, 6-7000 ft. [Chitral to Kumaon].

21. *Ixias pyrene*, (Linn.) Mus. Ulr., 241 (1744) (*Papilio*); Bingham, FBI., 2:193 (1907).

*Sutlej valley. [Throughout India; China; Malayan Subregion].

22. *Pieris brassicae,* (Linn,) , Syst. Nat., 10:467 (1758) ; Bingham, FBI., 2:170 (1907).
    *N. W. Himalayas. [Chitral to Bhutan, 10,000 ft.; Europe; N. and Central Asia].

23. *Pieris callidice,* (Esper.) Schmett. 1,2 pl. 115 (1800); Bingham, FBI., 2:178 (1907).
    *N. W. Himalayas, above 12,000 ft. [Chitral to Musoori Europe; in Asia from Altai Mts. to Himalayas; China].

24. *Pieris callidice kalora,* Moore, PZS., 449 (1865); Talbot, FBI., FBI., 1:415 (1939).
    *N. W. Himalayas: Manali, Parbati Valley, Sutlej Valley, Hamta. [N. W. F. P.: Safed Koh to Chitral and Kumaon].

25. *Pieris napi ajaka,* Moore, PZS., 490 (1865); Talbot, FBI., 1:1420 (1939).
    *Murree. [Kumaon].

26. *Pontia daplidice moorei,* (Röber.), Seitz. Macrolep., Fauna Palaearctica, 0419 (19Talb:ot, FBI., 1:431 (1939).
    *Parbati valley; Sutlej valley; Manali; Hamta. [Baluchistan to Chitral; Tibet; Yunnan].

27. *Terias laeta,* Boisduval, Sp. Gen. Lep., (1836); Bingham, FBI., 2:248 (1907).
    *N. W. Himalayas. [Afghanistan to Bhutan; Punjab W. India; Ahmednagar; Karachi; Poona; Bombay; S. India; Nilgiris; Anamalai Hills; Assam; Burma; Tenasserim].

28. *Terias libythea,* (Fabr.), Ent. Syst. Suppl., 427 (1798) (*Papilio*); Bingham, FBI., 2:247 (1907).
    *Kangra. [Kangra and Simla to Bhutan; Punjab; Bengal; Ganjam; W. India; Poona; S. India; Niligiris; Anamalai Hills; Ceylon; Assam; Burma; Tenasserim].

Family Nymphalidae

29. *Argynnis altissima mackinnoni.* Niceville, JBNHS., 4:346 (1891); Bingham, FBI., 1:445 (1905).
    *Western Himalayas; Sutlej valley; Parbati valley; Manali; Hamta; Gonas Pass, 15,000 ft.

30. *Argynnis clara,* Blanchard, in Jacquemont Voy. dans l'Inde, 4:20 (1844); Bingham, FBI., 1:443 (1905)
    *Sutlej valley.

31. *Argynnis jainadeva,* Moore, Ent. Month, Mag., 1:131 (1864); Bingham, FBI., 1:433 (1905).
    *Sutlej valley; Parbati valley; Manali; Hamta; about 9000 ft. [Chitral to Kumaon].

32. *Argynnis lathonia issaea*, Double., in Gray's Lep. Ins. Nepal, 11 (1846); Bingham, FBI., 1:441 (1905).
*N. W. Himalayas. [Chitral to Sikkim; Chin Hills (Upper Burma); W. China].

33. *Argynnis maia*, (Cramer), Pap. Exot., 1(1775) (*Papilio*); Bingham FBI., 1:434 (1905).
*Near Gilgit. [S. E. Germany; S. Europe; W. Asia].

34. *Argynnis pales*, (Denis & Schiff.), Wien, Verz., 177 (1776) (*Papilio*) Bingham, FBI., 1:447 (1905).
*Kashmir; Kulu: Parbati valley, Manali, Hamta; Sutlej valley. [Sikkim : Chumbi valley; Lapland to Russia Siberia, Altai Mts., N. Mongolia].

35. *Argynnis pales generator*, Staudinger, Stett, ent. Zeit., 235 (1886) Bingham, FBI., i:449 (1905).
*North Ladak. [Hunza valley; Chitral; Turkestan Afghanistan].

36. *Dilipa morgiana*, (Westwood), Dblday., Westw. & Hew. Gen. Di. Lep., 2:355 (1851) (*Apatura*); Bingham, FBI., 1:236 (1905).
*Dharamsala. *[Dharmsala to Sikkim; Assam; Upper Burma].

37. *Dophla patala*. (Kollar]; Hügel's Kaschmir, 4(2]:435 (1844) (*Adolias*); Bingham, FBI., 1:264 (1905).
*Chumba. [Chamba to Nepal].

38. *Karanasa digna*, (Marsh.], JASB., 67(1882) (*Hipparchia*); Bingham FBI., 1:125 (1905).
*Kashmir. [Chitral].

39. *Erebiaa nnada hybrida*, Butler, PZS., 147 (1880); Bingham, FBI., 1; 151 (1905).
*Western Himalayas: Sutlej valley. [W. Himalayas to Mussoorie and Kumaon].

40. *Eia shallada*, Lang, M. & de N. J. A. S. B., 247 (1880); Bingham FBI., 1:149 (1905).
*Western Himalayas, 12,000 ft.

41. *Lethe confusa*, Aurivillius, Ent. Tids., 142 (1897); Bingham, FBI. 1:82 (1905).
*Sutlej valley; Parbati Valley; Hamta.
[Simla to Sikkim; Assam; Burma; Tenasserim; Java].

42. *Lethe insana*, (Kollar), Hügel's Kaschmir, 4:448 (1844) (*Satyrus*); Bingham, FBI., 1:181 (1905).
*N. W. Himalayas. [N. W. to E. Himalayas; Bhutan; Assam].

43. *Lethe pulaha*, (Moore), Cat. Lep. Mus. E.I.C., 1:227 (1857)(*Lasiommata*); Bingham, FBI., 1:102 (1905).
*Chamba. [Chamba to Sikkim; Assam; Naga Hills Burma; East Pegu].

44. *Lethe rohria*, (Fabr.) Mant. Ins., 2:45 (1787) (*Papilio*); Bingham, FBI., 1:80 (1905).
*Kashmir. [Kashmir to Sikkim; Bhutan; Tenasserim;) Burma; China].

45. *Maniola pulchella*, (Felder), Novera Reise, Lep. Rhop., 490 (1867) (*Epinephele*); Bingham, FBI., 1:121 (1905).
*Sutlej valley; Parbati valley; Manali; Hamta; Ladak Kashmir. [Chitral].

46. *Melitaea sindura*, Moore, PZS., 496 (1865); Bingham, FBI., 1:451 (1905).
*Sutlej valley; Parbati valley; Manali; Hamta. [Tibet, over 10,000 ft.; Kunawar to Sikkim].

47. *Melitaea sindura balbita*, Moore, PZS., 268 (1874); Bingham FBI., 1:452 (1905).
*Confined to high elevations in Kashmir.

48. *Mycalesis perseus* (Fabr.), Syst, Ent., 488 (1775) (*Papilio*); Bingham, FBI., 1:57 (1905).
*Kangra. [Kangra to Sikkim; Bengal; S. India; Burma; China; Malayan subregion].

49. *Neptis zaida*, Doubleday, in Dblday., Westw. & Hew. Gen.Di. Lep., 272 (1850); Bingham, FBI., 1:336 (1905).
*Murree. [Murree to Sikkim].

50. *Nytha baldiva lehana*, Moore), AMNH., 1(5):227 (1878) (*Hipparchia*); Bingham, FBI., 1:115 (1905)
*Ladak. [Hunza; Chitral].

50. *Nytha diffusa*, (Butler), PZS., 147 (1880) (*Hipparchia*); Bingham, FBI., 1:115 (1905).
*N. W. Himalayas, basin of Ravi River.

51. *Orinoma damaris*, Gray, Lep. Ins. Nep., 14(1846); Bingham, FBI 1:106 (1905).
*Kangra. [Kangra to Sikkim above 2000 ft.; Bhutan; Assam the Khasi Hills; Upper Burma; Rubi Mines; Tenasserim].

52. *Parage ariana*,
*Sutlej Valley.

53. *Parhestina nicevillei*, Moore, Lep. Ind., 3:37 (1896-99); Bingham, FBI., 1:241 (1905).
*Chamba

54. *Satyrus schakara*, Kollar, Hügel's Kaschmir, 4(2); 446 (1844); Bingham, FBI., 1:110 (1905).
*Sutlej valley. [Himalayas eastwards up to Sikkim].

55. *Vanessa urticae*,
*Sutlej valley; Parbati valley; Manali; Hamta.

56. *Vanessa xanthomelaena*, (Denis & Schieff.), Wien, Verz., 176 (1776) (*Papilio*); Bingham, FBI., 1:369 (1905).
*Kashmir. [E.Europe; Kashmir to Mussoorie; China; Japan].

57. *Ypthima avanta*, Moore, PZS., 567 (1874); Bingham, FBI., 1:140 (1905).
*Kashmir; Kulu. [Simla to Kumaon; Bengal Orissa; Burma; Tenasserim]

58. *Ypthima baldus*, (Fabr.), Syst.Ent., 829 (1775)(*Papilio*); Bingham, FBI., 1:134 (1905).
*Chamba. [Sikkim to Bhuttan; Bengal; Central, Western and Southern India; Assam; Burma and Tenasserim].

Family Lycaenidae

59. *Lampides boeticus*, (Linn.) Syst. Nat., 1(12):789 (1767)(*Papilio*); Binghan FBI., 2:432 (1907). (*Polyommatus*).
*Kashmir. [Calcutta].

60. *Tarucus venosus*, Moore, PZS., 245 (1882); Bingham, FBI., 2:419 (1907).
*N. W. Himalayas: Murree. [N.W. Himalayas to Kumaon; Punjab:Campbellpore, Thundiani; Bengal Malda].

61. *Zizera otis*, (Fabr.), Mant. INs., 2:73 (1787); Bingham, FBI., 2:360 (1907).
*Sutlej valley. [Kumaon; Sikkim; Bengal; Orissa; C. & W.& S. India; Ceylon; Assam; Burma; Tenasserim Malaya; Java; China].

Family Nemeobidae

62. *Dodona dipaea*, Hewitson, Ex. Butt., 3(1886); Bingham, FBI., 1:482 (1905).
Kulu. [Kulu to Sikkim; Bhutan; Assam; Naga Hills].

63. *Dodona durga*, (Kollar) Hugel's Kaschmir, 4(2):441 (1844)(*Melitaea*); Bingham, FBI., 1:481 (1905).
*Kashmir. [Kashmir to Nepal].

64. *Dodona eugenes*, Bates, J.L.S. Zool., 9:371(1867); Bingham, FBI., 1:484 (1905).

*Murree. [Murree to Bhutan; Assam; Khasi Hills; Jaintea Hills].

Family Saturniidae

65. *Antheraea assama,* Westw., Cab. Or. Ent., 41(1848); Hampson, FBI., 1:20 (1892).
*Kangra. [Kangra to Assam; Pondicherry].

66. *Antheraea roylei,* Moore, PZS., 256 (1869); Hampson, FBI., 1:18 (1892).
*Kangra. [Mussoorie; Sikkim; Khasi Hills].

Family Brahmaeidae

67. *Brahmaea wallichii,* Gray, Zool. Misc., 39; Hampson, FBI., 1:30 (1892).
*Manali: Solang valley. [Nepal; Sikkim; Khasi Hills; Assam; Upper Burma].

Family Bombycidae

68. *Mustilia hepatica,* Moore, Lep. Atk., 82 Hampson, FBI., 1:39 (1892).
*Murree. (Sikkim).

69. *Theophila huttoni,* Westw., Cab. Or Ent., 26 (1848) ; Hampson, FBI., 1 35 (1892).
*N. W. Himalayas. [Sikkim; Assam].

Family Eupterotidae

70. *Eupterote undata,* Blanch., Jacq. Voy. Inde, Zool. Ins., 23 (1844); Hampson, FBI., 1:54 (1892).
*Dharmsala. [Throughout India as far south as the Burma].

Family Sphingidae

71. *Callambulyx poecilus,* (Roths)., Nov. Zool., 5:604 (1898); Hampson, FBI., 5:231 (1937).
*Murree.

72. *Cechenena lineosa scotti,* Roths., AMNH., 5 (9):481 (1920); Bell & Scott, FBI., 5:489 (1937).
*Dharamsala. [Simla; Massoorie].

73. *Cechenena minor minor,* (Butl.), PZS., 249 (1875) (*Chaerocampa*); Bell & Scott, FBI., 5:487 (1937).
*Dharamsala. [Simla; Sikkim; Bhutan; Khasi Hills, China; Japan; Siam].

74. *Celerio euphorbiae nervosa,* Roth. & Jord., Revision of Sphingidae, 721 (1903) Bell & Scott, FBI., 5;404 (1937).
*Ladakh foot of Zoji La Pass, Kashmir Changla Gali. [Sabathu].

75. *Dilephila euphorbiae,* Linn., Syst. Nat., 1;802 (1766); Hampson, FBI., 1:98 (1892).

*N. W. Himalayas. [N. W. Himalayas to Nainital; Europe].

76 *Gurelca masuriensis*, (Butl.),PZS., 244 (1875 (*Lophura*); Bell & Scott, FBI., 5:334 (1937).
*Bukloh. [Simla; Mussoorie].

77. *Haemorrhagia fuciformis fuciformus* (Linn). Syst. Nat., 10:493 (1758) (*Sphinx*); Bell & Scott, FBI., 5:242 (1937).
*Kangra. [Europe; North Africa].

78. *Langia zenzeroides*, Moore, PZS., 567 (1872); Hampson, FBI., 1:37 (1892 .
*Dharmsala. [Simla; Sikkim; Assam].

79. *Macroglossum stellatarum*, (Linn.) Syst. Nat., 10:514 (1758` (*Sphinx*); Bell & Scott. FBI., 5:352 (1937).
*Murree. [Karachi; S. India; Europe; Japan; Cochin -China; North Africa].

80. *Pergesa elpenor rivularis*, (Boisd.). Spec, Gen Lep. Het., 1:280 (1875) (*Chaerocampa*); Bell & Scott, FBI., 5:410 (1937).
*N. W. Himalayas. [Chitral to Sikkim; Simla; Darjeeling; Karachi].

81. *Pseudodolbina of celator*, Jordan Nov. Zool., 33:379 (1926); Bell & & Scott, FBI., 5:87 (1937).
*Dharmsala. [Simla; Mussorie].

82. *Rhopalpsyche nycteris nycteris*, (Koll), Hügel's Kaschmir, 4:458 (1848) (*Macroglossa*); Bell & Scott, FBI., 5:394 (1937).
*Kashmir; Murree; Kulu. [Sikkim; Bhutan;E. Himalayas; Khasi Hills; Burma; China].

Family Notodontidae

83. *Dicranura himalayana*, Moore, PZS., 400 (1888) Hampson, FBI., 1:158 (1892) *Dharmsala.

84. *Gargetta costigera*, Wlk., Wlk. Cat., 32:455 (1865) Hampson, FBI., *1:135(1892).
N. W. Himalayas:Mandi. [Sikkim. Moulmein].

85. *Hvperaesclra basistriga*, Moore, PZS., 400 (1888); Hampson, IIFBI., 1:164 (1892).
*Kangra; Dharamsala.

86. *Lophopteryx ferruginosa*, Moore, Lep. Atk., 67. Atk., 67:; Hampson FBI., 1:167 (1892).
*Murree. [Sikkim; Naga Hills].

87. *Phesia fasciata*, Moore, PZS., 401 (1888); Hampson, FBI., 1:160 (1892).
*Dharmsala [Sikkim].

88. *Spatalia plusioides*, Moore, Lep. Atk., 62; Hampson, FBI.,1:170 (1892).
*Kangra. [Sikkim; Nagas].

Family Cymatophoridae

89. *Habrosyne derasa*, Linn., Syst. Nat., 851 (1766); Hampson, FBI., 1:178 (1892).
*Dharamsala. [Sikkim; Burma; Europe].

90. *Polyploca albidisca*, Warr., PZS., 299 (1888); Hampson, FBI., 1:183 (1892)
*Kangra.

91. *Polyploca orbicularis*, Moore, PZS., 407 (1888); Hampson, FBI., 1:183 (1892).
*Dharamsala. [Sikkim].

92. *Polyploca renalis*, Moore, PZS., 407 (1888); Hampson, FBI., 1:183 (1892).
*Dharamsala.

Family Sesiidae

93 *Sciapteron flammans*, Hampson, FBI., 1:191 (1892),
*Murree.

Family Syntomidae

94. *Syntomis cyssea*, Cram., Pap. Exot., 4:124; Hampson, FBI., 1:213 (1892).
*Kangra. [Kangra to Sikkim; Contenental India and Ceylon].

95. *Syntomis diaphana*, Koll., Hügel's Kaschmir, 4:460 (1844); Hampson, FBI., 1:216 (1892).
*Kashmir. [Mussoorie; Almora; Sibsagar; Burma].

96. *Syntomis musa*, Swinh., PZS., 290 (1885); Hampson, FBL., 1:222 (1892).
*Kangra. [Naga Hills; Bombay; Nilgiris; Ceylon; Burma].

96-A. *Amata xanthograpta*, Hampson, Cat. Phal. Suppl., 1 : 32 (1914).
*Kashmir.

96-B. *Ceryx imaon*, (Cramer), Pap. Exot., 3 : 94(1780) (*Shphipnx*);
*Kashmir; Kangra. [Sikkim; Darjeeling; Khasis; Shillong; Cachar; Calcutta; Bombay].

Family Yponomentidae

97. *Ethnia assamensis*, (Butl.), T. E. S., 6 (1879).
*Dharmsala; Kulu; Kashmir. [Mussoorie; Khatmandu; Darjeeling; Bhutan; Khasis; Naga Hills; Cachar].

98. *Ethnia ermineella*, (Walsingham), PZS., 90 (1800) (*Psecadia*).
*Dharmsala. [Rawalpindi; Kurseong; Darjeeling].

99. *Ethnia pagiopa,* Meyr., Exot. Micr., 2 : 189-190 (1918).
*Kashmir, 6000 ft.

100. *Prays acmonias,* Meyr., B. J. 23:125-126 (1914).
*Murree. [Rawalpindi].

101. *Roeslerstammia hemiadelpha,* Meyr., Exot. Micr., 2 : 553 (1922).
*Murree, 7500 ft.

102. *Roeslerstemmia metaplastica,* Meyr., Exot. Micr., 2 : 439 (1921).
*Murree.

103. *Yponomeuta corusea,* (Meyr)., B. J. 23: 127 (1914) (*Hyponomeuta*); *Dharmsala.

104. *Zelleria petrias,* Meyr., B. J., 17 : 746 (1907).
*Dalhousie. [Simla; Kasauli; Bhimtal; Kanara; N. Coorg; Ootacamund].

Family Phaloniidae

105. *Euxanthis innotatana,* (Warren), PZS., 337 (1888) (*Xanthostia*)
*Punjab Hills; Kala Pani; Kashmir: Dras, Ladakh.

106. *Phalonia thermoconis,* Meyr., Exot. Micr., 3 : 139 (1925).
*Kashmir: Srinagar. [Kumaon: Muktesar, 7000 ft.]

Family Alucitidae

107. *Oidamatophorus mondactylus,* (Linn.), Syst. Nat., (ed. 10), 1 : 542 (1758) (*Phalaena*).

*Kashmir: Srinagar, Parachinar. [Hazara; Mussoorie; C.Asia; N. Persia; Siberia; Turkestan; Russia; Europe; Sicily Switzerland; British Isl., N. Africa; Egypt; E. Africa; N. America; Maxico etc.]

108. *Platyptilia exaltata,* Zeller, Stett. Ent. Ztg., 28 : 411-12 (1867).
*Dharmsala, Kukti. [Simla Muktesar 7000 ft; Sikkim; Darjelling; Assam: Shillong; Cherrapunji].

109. *Platyptilia gonodactyla,* (Schiff.), Verz. Schemett. Wirn., 320 (1775) (*Alucita*).

*Murree. [Rawalpindi; Darjeeling; C. Asia; N. Asia; Asia Minor; Europe.]

110. *Platyptilia rhododactyla,* (Schiff)., Wien. Verz., 146 (1775) (*Alucita*).
*Srinagar. [Asia Minor; C. Asia; N. Asia; Europe; N. America].

111. *Trichoptilus wahlbergi,* (Zeller), Linn. Ent., 6 : 346-348 (1852) (*Pterophorus*).

*Dharmsala; Parachinar. [Peshawar; Abbottabad; Shillong; Pusa; Ganjam; Bangalore; Coorg; Coimbatore; Kodaikanal; Palni Hills; Ceylon; E. Australia; S. Africa; Mauritius; Rodriguez; Seychelles; St. Helena].

Family Zygaenidae

112. *Akesina basalis*, (Moore, PZS., 396 (1888) (*Anomoeotes*). Hampson, FBI, I : 286 (1892).
*Kangra.

113. *Artona quadrimaculata*, Moore, PZS., 390 (1879).
*Kangra; Dharmsala. [Mussorie; Ramgarh; Muktesar [Kumaon.]

114. *Artona zebraica zebraica*, Butl., J. Linn. Soc., 12 : 365 (1876).
*Kulu; Mandi; Kangra. [Mussoorie; Almora; Kumaon Sikkim].

115. *Boradia carneola*, Moore, PZS., 392 (1879).
*Kangra; Dharmsala. [Simla].

116. *Campylotes histrionicus*, Westwood, Royle's Bot. Him., Lep., 53 (1839); Hampson, FBI., 1 : 274-75 (1892).
*Kashmir. [Throughout Himalayas; Afghanistan; N. W. India; Jeolikot; Mussoorie; Sikkim; Lebong; Raitdong, 9-10,000 ft.; Khasis; Shillong; Cherrapunji; W. China].

117. *Chalcosia pectonicornis albata*, Moore, PZS., 390 (1879); Hampson, FBI, 1 : 265 (1892).
*N. W. Himalayas; Dharmsala. [Jeolikot; Khatmandu].

118. *Clelea stipata*, (Wlk.), Walk. Cat., 1 : 114 (1854); Hampson, FBI, 1 : 232 (1892).
*Kangra. [Sikkim; Shillong; Cherrapunji; Bermardmyo; W. China; Japan].

119. *Epizygaena asoka*, (Moore), PZS., 389 (1879) (*Zygaena*).
*N. W. Himalayas: Kashmir.

120. *Eterusia pulchella pulchella*, (Kollar), Hügel's Kashmir, 4 (2): 461 (1844) (*Chalcosia*).
*Kashmir. [Afghanistan; Dungagali; Mussoorie; Kumaon Hills; Darjeeling; Khasis; Shillong; Sylhet; Cheerrapunji; Maymyo; Bernardmyo; Kalaw (Burma); W. China; C. China].

121. *Gynautocera papilionaria*, Guen., Mag. Zool., 12 (1830).
*Kashmir. [Jeolikot; Sikkim; Kalimpong; Bhutan; Assam; Nagas; Sylhet; Khasis; Shillong; Bassein; Tenasserim; Annam; Tonkin; Hainan].

122. *Tasema bipars*, Wlk., Wlk., Cat., 7 : 1597 (1856).
*Kangra. [Simla; Nagas; Khasis].

Family Pshychidae

123. *Acanthopsyche (Dasaratha) himalayana* Moore, PZS, p. 397 (1888); Hampson, FBI 1 : 394 (1892)
*Punjab: Dharamsala.

124. *Mahasena hockingi*, Moore, PZS; 397 (1888); Hampson FBI, 1:302 (1892)
*Kangra.

125. *Psyche (Barandra) funata* Moore, PZS; 396 (1888); Hampson, FBI 1:300 (1892)
*Dharamsala.

126. *Psyche (Eurycyttarus) decemvena* Hampson, FBI, 1:300 (1892).
*Kiris and Goorias Valley, Kashmir, 8000ft.

127. *Psyche (Eurycyttarus) nigra* Hampson, FBI, 1:299 (1892)
*Kala, Kashmir.

Family Cossidae

128. *Zeuzera multistrigata* Moore, PZS; 327 (1881); Hampson, FB. 1:311 (1892)
*Dharamsala. [Sikkim; Nagas].

Family Hepialidae

129. *Palpifer sexnotatus* Moore, PZS; 413 (1879); Hampson, FBI FBI, 1:317 (1892).
*Dharmsala. [Sikkim].

Family Drepanulidae

130. *Drepana lilacina* Moore, PZS; 401 (1888): Hampson, FBI, 1:336 (1892).
*Dharmsala; Kangra. [Sikkim].

131. *Drepana violacea*, Butl., III. Het., 7:42 (1889); Hampson, FBI 1:336 (1892)
*Dharmsala.

132. *Euchera substigmaria*, Hubn., Hubn. Zutr., 3:29 ( ); Hampson FBI, 1:327 (1892)
*Dharmsala. [Nepal; Sikkim; Assam; Burma].

133. *Macrauzata fenestraria*, Moore, PZS., 639 (1867); Hampso FBI, 1:330 (1892)
*Kangra. [Japan; Sikkim].

134. *Macrocilix mysticata*, Walk, Walk. Cat., 26:1617 (1862); Hampson, FB, 1:329 (1892)
*Dharamsala. [Sikkim].

Family Thyrididae

135. *Hypolamprs striatalis*, Swinh., PZS., 875 (1885); Hampson, FBI, 1:365 (1895)
*Dharmsala. [Calcutta; Poona; Nilgiris; Ceylon].

136. *Hypolamprus subrosealis* Leech, Entom., 66 (1889)); Hampson, FBI., 1:366 (1892)
*Dharmsala. [China; Ceylon].

Family Limacodidae

137. *Altha nivea*, Wlk., J. Linn. Soc., 6:173; Hampson, FBI., 1:397 (1892).
*Kulu. [Simla; Sikkim; Sibsagar; Ranchi; Ganjam; S. India; Ceylon].

138. *Cania bilinea*, Wlk., Wlk. Cat.; 5:1142 (1856); Hampson, FBI., 1:395 (1892).
*Dharmsala. [Sikkim; Ganjam; S. India; Malaca; Java; China].

139. *Contheyla melanosticta*, Hmpsn., FBI., 1:385 (1892).
*N. W. Himalayas: Mandi. [Jubbulpore].

140. *Miresa inornata*, Wlk., Walk. Cat., 5:1125 (1856); Hampson, FBI., 1:386 (1892) .
*N. W. Himalayas. [Nagas; China; Japan].

141. *Natada nararia*, Moore, Lep. E. I, Co., 415; Hampson, FBI., 1:381 (1892).
*Dharmsala. [Mhow; Nilgiris; Ceylon].

142. *Parasa pastoralis*, Butl., AMNH., 6(5):63; Hampson, FBI., 1:389 (1892).
*Dharmsala. [Sikkim; Bhutan; Nagas].

Family Lasiocampidae

143. *Arguda flavovittata*, (Moore), Lep. Atk. 79 (1879); (*Radhica*); Hampson FBI., 1:412 (1892).
*Kashmir Dharmasala. [Musoorie; Nainital; Bhutan].

144. *Bhima undulosa*, (Walker), Wlk. Cat., 6:1477(1855) (*Poecilocampa*); Hampson, FBI., 1:404 (1892).
*Kangra. [Nepal; Sikkim; Darjeeling; Khasis; Cherrapunji; Manipur; S. India; Sunda Isls].

145. *Dendrolimus ampla*, (Walker), Wlk. Cat., 6:1412 (1855) (*Odenestis*); Hampson, FBI., 1:4190 (1892).
*Kangra. [Sikkim; Bhutan; Khsis; Shillong; Sylhet; Burma; Sumatra; Java; Philippines].

146. *Dendrolimus fia*, (Swinhoe), AMNH, 7(3):113(1899) (*Lendora*).
*Kashmir.

147. *Dendrolimus hyrtaca*, (Cramer), Pap. Exot., 3:249 (1780) (*Bombyx*); Hampson, FBI., 1:410 (1892).
*Dharmsala. [E. Himalayas; Kalimpong; Pusa; Calcutta; Assam; Bombay; Mhow; Balghat; Ganjam; Madras; Trivandrum; Ceylon; Rangoon; Sunda Isls; China].

148. *Dendrolimus latipennis*, (Wlaker), Wlk. Cat., 6:1457 (1855) (*Lebeda*); Hampson, FBI., 1:409 (1892).
*Dharmsala. [Sikkim; Darjeeling; Khasis; Shillong; Cherrapunji Calcutta; Ceylon; Burma; Java; Borneo].

149. *Gastropacha undulifera*, Walk., Wlk Cat., 6:1395 (1856); Hampson. FBI., 1:428 (1892).
*Dharamsala.

150. *Lebeda nobilis*, Walker, Wlk. cat., 6:1456 (1855); Hampson, FBI., 1:407 (1892).
*Kashmir; Kangra. [Simla; Mussoorie; Nepal; Bhutan; Sylhet; Shillong; Cherrapunji; Nagas]

151. *Suana concolor*, (Walker), Wlk. Cat., 6:1463 (185) (*Lebeda*); Hampson, FBI., 1:406 (1892).
*Kashmir. [Throughout India; Sikkim; Bhutan; Sylhet Shillong; Cherrapunji; Coorg; Ceylon; Sumatra; Java; Philippines].

Family Lymantriidae

152. *Arora plana*, Wlk., Wlk. Cat., 4:786 (1855); Hampson, FBI., 1:438 (1892).
*Kangra. [Calcutta; Nilgiris; Ceylon].

153. *Euproctis anguligera*, But l., PZS., 385 (1886): Hampson, FBI., 1:476 (1892).
*Murree. [Burma; Andamans].

154. *Euproctis bipunctapex*, Hampson, Ill. Het., 8:57 (1891); FBI, 1:484 (1892).
*Kangra. [Nagas; Nilgiris; Burma; China].

155. *Euproctis plana*, Wlk., Wlk. Cat., 7:1731 (1856); Hampson, FBI., 1:479(1892).
*Kangra. [Sikkim; Burma; Andamans].

156. *Euprocits sulphurescens*, Moore, PZS., 399 (1888): Hampson, FBI, 1:474 (1892).
*Kangra.

157. *Laelia litura*, Wlk., Wlk. Cat., 4-797 (1855); Hampson, **FBI.**, 1:443 (1892).
*Kulu. [Nepal; Sikkim; Tenasserim].

Family Arctiidae

158. *Aemene sagittifera*, Moore, PZS., 392 (1888); Hampson, FBI., 2:93 (1894).
*Kangra. [Sikkim].

159. *Aemene taprobanis*, Wlk., Wlk. Cat., 2:542 (1854); Hampson FBI., 2:92 (1894).
*Kangra. [Sikkim; Nagas; Nilgiris; Ceylon].

160. *Alphaea obliquifascia*, Hampson, FBI., 2:24 (1894).
*Dharmsala. [Assam; Burma; . Java].

161. *Anachrostis bifasciata*, Hampson, FBI., 2:100 (1894).
*Murree. [Simla].

162. *Anachrostis inconstans*, Moore, PZS., 393 (1888); Hampson, FBI., 2:100 (1894).
*Kangra.

163. *Cyana gelida*, Walk. Cat., 2:529; Hampson, FBI., 2:60 (1894).
*Kangra. [Sikkim; Sylhet].

164. *Cyana puella*, Drury, Ill. Exot. Ins., 2:3; Hampson, FBI., 2:57 (1894).
*Dharmsala. [Nepal; Bombay; S. India; Ceylon; Java].

165. *Lithosia nigrifrons*, Moore, PZS., 572 (1872); Hampson, FBI, 2:84 (1894).
*Kangra. [Sikkim; Nagas; Japan].

166. *Lithosia pallens*, Moore, PZS., 19 (1878); Hampson, FBI., 12:85 (1894).
*Kangra. [Kurseong; Sikkim].

167. *Lithosia pallida*, Moore, PZS., 21 (1888); Hampson, FBI., 2:83 (1894).
*Kangra.

168. *Miltochrista linga*, Moore, Cat. E. I Co., 301; Hampson, FBI., 2:110 (1894).
*Kangra. [Sikkim].

169. *Miltochrista palmata*, Moore, PZS., 31 (1878); Hampson, FBI., 2:110 (1894).
*Kangra. [Sikkim; Assam].

170. *Miltochrista undulosa*, Walk. Cat., 2:545 (1854); Hampson, FBI., 2:108 (1894).
*Kangra. [Sikkim; Khasis; Moulmein].

171. *Nola angulata*, Moore, PZS., 393 (1888); Hampson, FBI., 2:140 (1894).
*Dharmsala. [Sikkim; Nilgiris; Ceylon.]

172. *Simareea basinota*, Moore, PZS., 798 (1865); Hampson, FBI., 2:90 (1894).
*Kangra. [Sikkim].

173. *Spilosoma bimaculatum*, Moore, PZS., 398 (1879); Hampson, FBI, 2:6(1894).
*Punjab: Palampur.

174. *Spilosoma casignetum*, Koll., Hügel's Kaschmir, 4:469 (1844) Hampson, FBI., 2:9 (1894).
*Kangra. [Kangra to Sikkim; Assam; Nagas; Manipur; Calcutta; Bombay; Nilgiris; Burma].

175. *Spilosoma dalbergiae*, Moore, PZS., 394 (1888); Hampson, FBI., 2:4 (1894).
*Kangra. [Sikkim; Khasis; Nagas].

176. *Spilosoma lacteatum,* Butl., Ill, Het., 5:31 (1881); Hampson, FBI., 2:10 (1894).
*Dharmsala. [Sikkim].

177. *Spilosoma sangaicum,* Wlk., Cat., 31:294 (1864); Hampson, FBI., 2:3 (1894).
*Murree. [Japan; China].

178. *Thyrgorina discalis,* Moore, PZS., 399 (1879): Hampson, FBI'. 2:13 (1894).
*N. W. Himalayas.

179. *Thyrgorina multivittata,* Moore, PZS 808 (1865); Hampson, FBI., 2:12 (1894).
*Murree. [Punjab; Sikkim; Nagas; Burma].

180. *Thyrgorina unifascia,* Walk. Cat., 3:774 (1855'; Hampson, FBI., 2:13 (1894).
*Kangra. [Mussoorie].

Family Agaristidae

181. *Aegocera venulia,* Cram., Pap. Exot., 2:pl. 165d.; Hampson, FBI., 2:158 (1894).
*Kashmir. [Sub-Himalayan tracts of Kashmir and Sikkim; and plains of India, Ceylon, Burma].

182. *Mimeusemia peshwa,* Moore, Cat. E. I. Co., 289; Hampson, FBI., 2:159 (1894).
*Kangra. [Sikkim.]

Family Noctuidae

183. *Acronycta denticulata,* Moore, PZS., 408 (1888); Hampson., FBI., 2;242 (1894)
*Dharmsala.

184. *Acronycta fasciata,* Moore, Lep. Ceyl., 3:5; Hampson., FBI., 2.243 (1894).
*Kangra; Dharmsala. [Ceylon; Rangoon.].

185. *Acronycta gastridia,* Swinh., AMNH., 15(6): 6; Hampson, FBI., 4 : 510(1896) *Murree.

186. *Acronycta pruniosa,* Guen., Guen Noct., 1:53 (1852); Hampson, FBI., 2:242 (1894).
*N. W. HimalayasI. [Sylhet; Ceylon; Java].

187. *Agrotis albipennis,* Butl., Ill., Het., 7:58 (1887);
Hampson, FBI., 2:186(1894).
*Dharmsala.

188. *Agrotis intracta,* Walk. Cat., 10:346 (1856); Hampson, FBI., 2:183 (1894).
*Dharmsala.

189. *Agrotis modesta,* Moore, PZS., 351 (1881); Hampson, FBI., 2:188 (1894).
*Dharmsala.

190. *Agrotis monticola,* Hampson, FBI., 2:183 (1894).
*Lahaul, 12000 ft.

191. *Agrotis niveisparsa.* Butt., Ill. Het., 7:54 (1889); Hampson, FBI., 2:187 (1894).
*Dharmsala.

192. *Agrotis ochracea,* Walk, Cat., 32:657 (1865); Hampson, FBI., 2:182 (1894).
*Dharmsala. [Rawalpindi; Thandiani; Sikkim; Ceylon].

193. *Agrotis pronuba,* Linn., Syst. Nat., 842; Hampson, FBI., 2:190 (1894).
*Dharmsala. [Europe].

194. *Agrotis putris,* Linn., Syst. Nat., 850; Hampson, FBI., 2:186 (1894).
*Dharmsala. [Europe; Japan].

195. *Amphipyra himalayica,* Hampson, FBI., 2:193 (1894).
*Murree.

196. *Amphipyra monolitha,* Guen. Noct., 2:414 (1852); Hampson, FBI., 2:191 (1894).
*Dharmsala. [Sikkim; North China; Japan].

197. *Auchmis cashmirensis,* Moore, PZS., 358 (1881); Hampson, FBI., 2:284 (1894).
*Kashmir.

198. *Berresa turpis,* Walk, Cat., 12:252 (1857); Hampson, FBI., 2:252 (1894).
*Dharmsala. [Nilgiris; Ceylon; Fiji; Tonga].

199. *Bombycia meterythra,* Hampson, FBI., 2:207 (1894).
*Murree.

200. *Bombycia persimilis,* Hampson, FBI., 2:206 (1894).
*Dharmsala.

201. *Bryophila glaucescens,* Butl., Ill. Het., 7:81 (1889); Hampson, FBI., 2:300 (1894).
*Dharamsala. [Rangoon].

202. *Bryophila nadgani,* Hampson, Ill. Het., 8:87 (1891); Hampson, FBI., 2:298 (1894).
*N. W. Himalayas. [Nilgiris; Western Slopes].

203. *Callopistria indica,* Butl., AMNH., 8(6):76; Hampson, FBI., 2:256 (1894).
*N. W. Himalayas. [Canara Borneo].

204. *Callyna siderea,* Guen. Noct., 1:113 (1852); Hampson, FBI., 2:356 (1894).
*Dharmsala. [Sylhet; Poona].

205. *Calpe bicolor,* Moore, PZS., 19 (1883); Hampson, FBI., 2:564 (1894).
*Kangra.

206 *Calpe rectistria,* Guen, Noct., 2:363 (1852); Hampson, FBI., 2:565 (1894).
*Dharmsala. [Sikkim; Sylhet].

207. *Caradrina externa,* Walk. Cat., 33:715 (1865) ; Hampson., FBI., 2:265 (1894).
*Dharmsala. [Punjab; Sikkim].

208. *Catada rasalis,* Warr., AMNH., 8(6):67 (1891) Hampson., FBI., 3:61 (1895).
*Dharmsala. [Ceylon].

209. *Catephia flavescens,* Butl., Ill. Het., 7:74 (1889) Hampson, FBI., 2:482(1894).
*Dharmsala. [Sikkim].

210. *Catocala prolifica,* Walk. Cat., 13: 1211 (1857); Hampson. FBI., 2:441(1894).
*N. W. Himalayas. [Sikkim; Baluchistan; Afghanistan].

211. *Chariclea bimaculata,* Moore, PZS., 411 (1888); Hampson., FBI,. 2:179 (1894).
*Dharmsala. [Sikkim; Nilgiris; Bhamo, Burma].

212. *Charcilea decorata,* Moore, PZS., 365 (1881); Hampson FBI., 2:177 (1894).
*Dharmsaa.

213. *Coarica fasciata,* Moore, Lep. Atk., 153; Hampson, FBI., 2:489 (1894).
*Murree. [Sikkim].

214. *Cosmia restituta,* Walk. Cat., 10:490 (1856); Hampson., FBI., 2:321 (1894).
*Murree. [Nepal].

215. *Cuculia albipennis,* Hampson, FBI., 2:239 (1894).
*Sultanpur, Kangra.

216. *Cuculia nigrifascia,* Hampson, FBI., 2:239 (1894).
*Murree.

217. *Cuculia stigmatophora,* Hampson, FBI., 2:239 (1894).
*Murree.

218. *Dendrothripa rufipuncta,* Hampson, FBI., 4:527 (1896).
*Kangra.

219. *Dinumma deponens*, Walk. Cat., 15:1806(1858); Hampson, FIB. 2:355 (1894).
*Dharmsala. [China; Japan].

220. *Dinumma placens*, Walk. Cat., 15:1803 (1858); Hampson, FBI. 2:355 (1894).
*Dharmsla. [Nilgiris; Ceylon; Rangoon].

221. *Diphthera pallida*, Moore, PZS., 46 (1867); Hampson, FBI., 2:95 (1894).
*Dharmsala. [Sikkim].

222. *Dipterygia umbrifera*, Butl., Ill. Het., 7:46 (1889); Hampson FBI., 2:236 (1894).
*Dharamsala.

223. *Epilecta semiherbida*, Walk. Cat., 11:743 (1857); Hampson, FBI, 2:193 (1894).
*Dharmsala. [Sikkim; Japan].

224. *Eublemma polygramma*, Dup. iii, Suppl., p. 519; Hampson, FBI, 2:339 (1894).
*Dharmasala. [Europe].

225. *Euplexia auroviridis*, Moore, PZS., 59 (1867) Hampson, FBI. 2:521 (1894).
*Dharamsala. [Bengal; Nagas; Nilgiris].

226. *Euplexia didyma*, Esp. Schmett. Eur., 2(4): 378; Hampson, FBI. (1894).
*Dharmsala. [Europe].

227. *Euplexia diminuta*, Butl., Ill. Het., 7:55 (1889); Hampson, FBI., 2:218 (1894).
*Dharmsala.

228. *Euplexia gemmifera*, Walk. Cat., 12:934 (1857); Hampson, FBI., 2:217 (1894).
*Dharmsala. [Sikkim; Poona: Nilgiris].

229. *Euplexia inepta*, Butl., Ill. Het., 7:55 (1889); Hampson, FBI., 2:218 (1894).
*Dharmsala.

230. *Euplexia lignea*, Butl., Ill. Het., 7:40 (1889); Hampson, FBI. 2:210 (1894).
*Dharmsala; Sultanpur.

231. *Euplexia pectinata*, Warr., PZS., 308 (1888); Hampson, FBI., 2:222 (1894).
*Dharamsala. [Nilgiris].

232. *Euplexia sodalis*, Butl., AMNH., 1(5):83; Hampson, FBI,. 2:210 (1894).
*Dharamsala. [Simla; Sikkim; Japan].

233. *Eurois chalybeata,* Walk. Cat., 32:665 (1855); Hampson, FBI., 4:510(1896).
*Kulu. [Sikkim; Khasis]

234. *Eurois lubrica,* Butl., Ill. Het., 7:60 (1889); Hampson, FBI., 2:223 (1894).
*Dharamsala.

235. *Eurois virens,* Butl., AMNH., 1(5):194 (1878); Hampson, FBI., 2:231 (1894).
*Dharmsala. [Thandiani; Sikkim; Japan].

236. *Eutelia inextricata* Moore, Lep. Atk., 147; Hampson, FBI., 2:395 (1894).
*N.W. Himalayas. [Sikkim; Assam; Ceylon; N. China].

237. *Fodina cuneigera,* Butl., Ill. Het., 7:79 (1889); Hampson, FBI., 2:530 (1894).
*Kangra. [Ganjam; Nilgiris].

238. *Goniocraspidum ennomoide,* Hampson, FBI., 2:416 (1894).
*Dharmsala; Murree.

239. *Hadena incisa,* Moore, PZS., 344 (1881); Hampson, FBI., (1894).
*Dharamsala.

240. *Hadena repetita,* Butl., Ill. Het., 7:52 (1889); Hampson., FBI., 2:202 (1894).
*Dharamsala.

241. *Hermonassa incisa,* Moore, Lep. Atk., 120; Hampson, FBI., 2:197 (1894).
*Dharmsala. [Sikkim].

242. *Hyela quadripartita,* Walk. Cat., 33:786 (1856); Hampson, FBI., FBI., 2:308 (1894).
*N. W. Himalayas. [W. India; Nilgiris].

243. *Hyela tegulata,* Butl., Ill. Het., 7·63 (1889); Hampson, FBI., 2:308 (1894).
*Dharamsala. [Nilgiris].

244. *Hyelopsis picata,* Butl., Ill. Het., 7:62(1889); Hampson, FBI., 2:305 (1894).
*Dharamsala. [Simla].

245. *Hyelopsis renalis,* Moore, Lep. Atk., 142; Hampson, FBI., 2:305 (1894).
*Dharamsala. [Calcutta; Ceylon; Tenasserim].

246. *Hyelopsis vialis,* Moore, Lep. Atk., 135; Hampson, FBI., 2:304 (1894).
*Dharamsala. [Sikkim; Nilgiris].

247. *Hylodes drylla,* Guen. Noct., 3:209 (1852); Hampson, FBI., 2:463 (1894).
*N. W. Himalayas. [Assam; Calcutta; Burma; Perak].

248. *Hypena longipennis*, Walk. Cat., 34:1139 (1865); Hampson, FBI., 3:76 (1895).
*Dharamsala. [Sikkim; Khasis].

249. *Hypena obductalis*, Walk. Cat., 16:56 (1858); Hampson, FBI., 3:83 (1895).
*Dharmsala. [Simla; Sikkim; Khasis].

250. *Hypena occata*, Moore, Lep. atk., 191; Hampson, FBI., 3 (1895).
*Dharamsala. [Sikkim; Khasis; Nilgiris & Ceylon].

251. *Hypernaenia violacea*, Butl., Ill. Het., 7:54 (1889); Hampson, 2:196 (1894).
*Dharamsala.

252. *Hypocala deflorata*, Fabr., Ent. Syst., 3:472; Hampson, FBI., 2:453 (1894).
*N. W. Himalayas. [Canara; Nilgiris; E. & S. Africa].

253. *Isoura fuscicollis*, Butl., Ill. Het., 7:56 (1889); Hampson, FBI., 2:506(1894).
*Dharmsala.

254. *Leucania abdominalis*, Moore, PZS., 338 (1881); Hampson, FBI., 2:273 (1894).
*Dharamsala. [Khandala; Bengal].

255. *Leucania albicosta*, Moore, PZS., 338(1881); Hampson, FBI 2:297 (1894).
*Dharmsala. [Sikkim; Khasis; Nagas; Nilgiris; Bernardmyo].

256. *Leucania distincta*, Moore, PZS., 333 (1881); Hampson, FBI., 2:277 (1894).
*Dharmsala. [Sikkim].

257. *Leucania fraterna*, Moore, PZS., 410 (1881); Hampson, FBI., 2: 2:267 (1894).
*Dharmsala.

258. *Leucania fragilis*, Butl., PZS., 160 (1883); Hampson FBI., 2:275 (1894).
*Dharmsala. [Simla; Chhindwara; C.P.]

259. *Leucania irrorta*, Moore, PZS., 341(1881); Hampson, FBI. 2:280 (1894).
*Kulu. [Punjab; Ceylon].

260. *Leucania l-album*, Linn., Syst. Nat., 7:850; Hampson., FBI., 2:270 (1894).
* N. W. Himalayas. [Sikkim; Burma; Nilgiris; Europe]

261. *Leucania obscura*, Moore, Lep. Atk., 97; Hampson, FBI., 2:277 (1894).
*Dharmsala. [Sikkim; Ceylon; Nagas; E. Pegu].

262. *Leucania paidicota*, (Moore), Lep. Atk., 97 (*albicosta*): Hampson, FB*ll*., 2:276 (1894).
*N.W. Himalayas, [Sikkim; Ceylon.]

263. *Leucania refistrigosa*, Moore, PZS., 337 (1881); Hampson, FBI., 2 : 270 (1894).
*Dharmsala. [Ambala; Sikkim].

264. *Leucania sinuosa*, Moore, Lep. Atk., 102; Hampson, FBI., 2 : 273 (1894).
*Dharmsala. [Sikkim; E. Pegú].

265. *Leucania uniformis*, Moore, PZS., 339 (1881); Hampson, FBI., 2 : 280 (1894).
*N. W. Himalayas.

266. *Leucania venalba*, Moore, PZS., 48 (1867); Hampson, FBI., 2 : 279 (1894).
*Dharmsala. [Khasis; Ceylon].

267. *Mastigophorus ? dubius*, Butl., Ill. Het., 7 : 89 (1889); Hampson, FBI., 3 : 49 (1895).
*Dharmsala.

268. *Mecodina cineratia*, Butl., Ill. Het. 3 : 27 (1879); Hampson, FBI., 3 : 3 (1895).
*N. W. Himalahas. [Sikkim; Khasis; Japan.]

269. *Mecodina subviolacaea*, Butl., Trans. Ent. Soc., 581 (1881); Hampson, FBI., 3 : 4 (1895).
*N. W. Himalayas. [Margharita; Assam; Japan].

270. *Metachrostis egens*, Moore, Ley. Cey., 3 : 68; Hampson, FBI., 2 : 325 (1894).
*Dharmsala. [Ceylon.]

271. *Metachrostis hypenoides*, Butl., Ill., Het., 7 : 65 (1889); Hampson, FBI., 2 : 328 (1894).
*Dharmsala. [Simla].

272. *Metachrostis incondita*, Butl., 7 : 69 (1889); Hampson, FBI., 2: 328 (1894).
*Dharmsala. [Bhutan; Calcutta].

273. *Metachrostis punctigera*, Walk. Cat., 42: 685 (1856); Hampson, FBI., 2 : 329 (1894).
*Dharmsala. [Throughout the Bombay & Madras Presidencies; China; Japan; Australia].

274. *Metachrostis unduligera*, Butl., Ill. Het., 7:63 (1889); Hampson, FBI., 2:328 (1894).
*Dharmsala. [Simla].

275. *Metachrostis venata*, Butl., Ill. Het., 7:70 (1889); Hampson, FBI., 2:330 (1894).
*Dharmsala.

276. *Naranga curvifera*, Walk, Trans. Ent. Soc. 3rd. ser., 1:91; Hampson FBI., 2:334 (1894).
*Dharamsala. [Peninsular India; Ceylon; Burma; Java; Formosa; Japan].

277. *Nodaria duplicinota*, Hampson, FBI., 3:58 (1895)
*Dharmsala. [Simla; Sikkim].

278. *Nodaria innocens*, Butl., Ill. Het., 3:63(1879); Hampson, FBI., 3:56(1895).
*Dharamsala. [Sikkim; Assam; Nilgiris; Japan].

279. *Nodaria palumbina*, Butl., Ill. Het., 7:88 (1889); Hampson, FBI, 3:57 (1895).
*Dharamsala. [Sikkim].

280. *Nodaria saccharivora*, Butl., Ill. Het., 7:87 (1889); Hampson, FBI., 3:58(1895).
*Dharmsala. [Simla; Sikkim; China].

281. *Nonagria chloroptera*, Hampson, FBI., 2:285 (1894).
*Kashmir.

282. *Ophiusa triphaenoides*, Walk. Cat., 14:1358 (1858); Hampson, FBI., 2:505(1894).
*N. W. Himalayas. [E. Himalayas; Bengal; W. & S. India].

283. *Plusia furcifera*, Walk. Cat., 12:927(1857); Hampson. FBI., 2:568 (1894).
*N. W. Himalayas. [Poona; Nilgiris].

284. *Plusia gutta*, Guen. Noct., 2:346(1852); Hampson, FBI., 2:57 (1894).
*Dharmsala. [Nilgiris; China; Japan; Europe].

285. *Plusia jessica*, Butl., AMNH., 1(6):201 (1878); Hampson, FBI. 2:568(1894).
*N. W. Himalayas. [Japan].

286. *Plusia oxygramma*, Hübn. Zutr., 37, figs. 769, 770· Hampson, FBI. 2:575(1894).
*N. W. Himalayas. [Nilgiris; Ceylon; Java; China; Japan: Georgia (Asia); Australia].

287. *Plusia pyropia*, Butl., AMNH., 4(5) 367; Hampson, FBI., 2:472 (1894).
*Dharmsala. [Sikkim; Nagas; Japan].

288. *Polydesma catenata*, Moore, Lep. Ceyl., 3:550; Hampson, FBI., 2:467(1894).
*Dharmsala. [Ceylon].

289. *Polydesma mundata*, Walk. Cat., 15:1701 (1859); Hampson, FBI., 2:465 (1894).
*Kangra. [Ceylon].

290. *Pseudoglossa fulvipicta*, But.., Ill. Het., 7:87 (1889); Hampson, FBI., 3:41 (1895).
*Dharmsala. [Nilgiris, Rangoon].

291. *Pseudophia indecisa*, Walk. Cat., 12:82 (1857); Hampson, FBI, 2:481 (1894).
*Murree. [Campbellpur; Aden].

292. *Raparna lilacina*, Butl., Ill. Het., 7:81(1889); Hampson, FBI., 3:27 (1895).
*Dharmsala.

293. *Raparna ochereipennis*, Moore, Lep. Atk., 178; Hampson, FBI., 3:25(1895).
*Dharmsala. [Calcutta; Poona; Nilgiris];

294 *Rhaesena transcissa*, Walk. Cat., 35:1974 (1886); Hampson, FBI., 3:103 (1895).
*Dharmsala. [Bombay; Calcutta; Ceylon; Rangoon; Borneo; Australia].

295. *Rhynchina pionealis*, Guen. Delt. et Pyr., 21(1854); Hampson, FBI,. 3:75(1895).
*Dharamsala. [Nilgiris; Japan].

296. *Rivula ochracea*, Moore, Lep. Atk., 197; Hampson, FBI., 2:336 (1894).
*Dharmsala. [Calcutta].

297. *Sypna rectilinea*, Moore, PZS., 70(1867); Hampson, FBI., 2:449 (1894).
*N.W. Himalayas. [Sikkim; Nagas].

298. *Sypna replicata*, Feld. Reis. Nov., pl. 117, fig. 25; Hampson, FBI., 2:450(1894).
*Dharmsala. [Sikkim; Shillong; Tavoy].

299. *Tarache crocata*, Guen. Noct., 2:218(1852); Hampson, FBI., 2:314(1894).
*Dharmsala. [Simla; Bombay; Coimbatore].

300. *Tarache lucida*, Hüfn. Berl. Mag., 3:302 (1767); Hampson, FBI., 2:310 (1894).
*N. W. Himalayas. [Campbellpur; Europe].

301. *Tarache olivea*, Guen. Noct., 2:217 (1852); Hampson, FBI., 2:313 (1894).
*Dharmsala. [Simla; Mhow].

302. *Toxophleps trilatalis*, Walk. Cat., 34: 1237 (1865); Hampson, FBI, 2 : 307 (1894).
*Dharmsala. (Simla).

303. *Trichanarta ladakensis*, Feld., Reis. Nov. pl. 108, fig. 38; Hampson, FBI., 4 : 508 (1896).
*Ladakh.

304. *Trisuloides sericea*, Butl., AMNH., 7(5): 36; Hampson ,FBI':2 436 (1894).
*N.W. Himalayas. [Sikkim; Shillong].

305. *Tympanistes rubidorsalis*, Moore, PZS., 409 (1888); Hampson, FBI., 2 : 421 (1894).
*Dharmsala.

306. *Xanthia melonina*, Butl., Ill. Het., 7 : 57 (1889); Hampson, FBI., 2 : 170 (1894).
*Dharmsala.

307. *Xanthia rectilineata*, Hampson, FBI., 171 (1894).
*Kulu; Sultanpur; Kangra.

308. *Xanthoptera argentifrons*, Butl., Ill. Het., 7 : 65 (1889); Hampson, FBI., 2 : 317 (1894).
*Dharmsala.

309. *Xanthopetra excisa*, Swinh., PZS., 455 (1885); Hampson, FBI., 2 : 318 (1894).
*Dharmsala. [Simla; W. India; Coimbatore].

310. *Xanthoptera marginata*, Walk. Cat., 35: 1775 (1866); Hampson, FBI., 2 : 36 (1894).
*Dharsmsala. [Nilgiris; Java].

311. *Xanthoptera plebeia*, Butl., Ill. Het., 7 : 61 (1889); Hampson, FBI. 2 : 319 (1894).
*Dharmsala. [Bhutan].

Family Epiplemidae

312. *Epiplema bicaudata*; Moore, PZS., 643 (1867); Hampson, FBI., 3 : 130 (1895).
*Dharmsala. [Sikkim; Khasis].

313. *Epiplema columbaris*, Butl., Ill. Het., 7 : 82 (1889); Hampson, FBI., 3 : 125 (1895).
*Dharmsala. [Simla].

314. *Gathynia simulanus*, Butl., Ill. Het., 7 : 81 (1889); Hampson, FBI., 3 : 135 (1895).
*Kangra.

Family Geometridae

315. *Acidalia amplipennis*, Butl., Ill. Het., 7 : 111 (1889); Hampson, FBI., 3 : 440 (1895).
*Dharmsala.

316. *Acidalia humeraria*, Walk., Cat., 26: 1606 (1862); Hampson, FBI., 3 : 434 (1895).
*Dharmslala.

317. *Acidalia lacteipennis*, Butl., Ill. Het., 6 : 107 (1889); Hampson, FBI., 3 : 441 (1895).
*Dharmsala.

318. *Anonychia rostrifera*, Warr., PZS., 330 (1888); Hampson, FBI., 3 : 178 (1895).
*Murree. [Thadiani].

319. *Arichanna marginata*, Warr., PZS., 423 (1893); Hampson, FBI., 3: 291 (1895).
*Dharmsala. [Sikkim; Bhutan; Khasis; Nagas].

320. *Arichanna sparsa*, Butl., Entom., 23: 316; Hampson, FBI. 3 : 294 (1895).
*Dharmsala.

321. *Arichanna transectata*, Walk. Cat., 24: 1112 (1862); Hampson, FBI., 3: 294 (1895).
*Chamba. [Kumaon; Sikkim].

322. *Biston suppressaria*, Guen. Phal., 1 : 210 (1857); Hampson, FBI., 3: 247 (1895).
*Kangra. [Sikkim; Assam; Calcutta; Ceylon; Japan].

323. *Boarmia atrilineata*, Butl., Trans. Ent. Soc., 405 (1881); Hampson, FBI., 3: 279 (1895).
*Dharmsala. [Sikkim; Japan].

324. *Boarmia punctigera*, Butl., Ill. Het., 7 : 113 (1889); Hampson, FBI., 3: 281 (1895).
*Dharmsala.

325. *Boarmia selenaria*, Hübn. Samml. Eur. Schmett., Geom., fig. 163; Hampson, FBI., 3 : 264 (1895).
*N. W. Himalayas. [Nepal; Khasis; China; Japan; Amur; Europe; Congo; S. Africa].

326. *Boarmia transcissa*, Walk. Cat., 21: 380 (1860); Hampson, FBI., 3 : 271 (1895).
*Dharmsala. [Sikkim; Bhutan; Assam; Nilgiris;Ceylon; Burma; Java].

327. *Boarmia tristis*, Butl., Ill. Het., 7 : 102 (1889); Hampson, FBI., 3 : 280 (1895).
*Dharmsala. [Simla].

328. *Caberodes achromaria*, Guen. Phal., 1 : 136 (1857); Hampson, FBI., 3: 159 (1895).
*Dharmsala. [Khasis].

329. *Chloroclystis lucinda*, Butl., AMNH., 4(5): 442; Hampson, FBI., 23: 396 (1895).
*Dharmsala. [Sikkim; Nilgiris; Ceylon; Japan].

330. *Chloroclystis palpata*, Walk. Cat., 25 : 1404 (1862); Hampson, FBI., 3 : 391 (1895).
*Dharmsala. [Sikkim; Nilgiris; Ceylon; Japan].

331. *Cnloroclystis recensitaria*, Walk. Cat., 24 : 1244 (1862); Hampson, FBI., 3 : 395 (1895).
*Dharmsala. [Nilgiris; Ceylon].

332. *Cidaria aurata*, PZS., 664 (1867); Hampson, FBI., 3 : 355 (1895).
*Murree; Dharmsala. [Sikkim; Bhutan; Tibet, Khasis].

333. *Cidaria ochreata*, Moore, Lep. Atk., 267; Hampson, FBI., 3 : 352 (1895).
*N. W. Himalyas. [Sikkim; Afghanistan].

334. *Cidaria niphonica*, Butl., AMNH., 1 (5): 452; Hampson, FBI., 3 : 357 (1895).
*Dharmsala. [Simla; Sikkim; Japan].

335. *Cidaria nivicincta*, Butl., Ill. Het., 7: 119 (1889); Hampson, FBI., 3 : 357 (1895).
*Dharmsala. [Khasis].

336. *Cidaria saturata*, Guen. Phal., 2 : 269 (1857); Hampson, FBI, 3 : 362 (1895).
*N. W. Himalayas. [Khasis: Nilgiris; China; Japan; Natal].

337. *Cidaria triangulifera*, Moore, Lep. Atk., 275; Hampson, FBI., 3: 358 (1895).
*Dharmsala. [Sikkim; Khasis].

338. *Corymica specularia*, Moore, PZS., 649 (1867); Hampson, FBI., 3 : 186 (1895).
*Dharmsala. [Sikkim; Nilgiris: Ceylon; Japan].

339. *Craspedia butyrosa*, Warr., PZS., 362 (1893); Hampson, FBI., 3 : (1895).
*Dharmsala. [Sikkim; Bhutan].

340. *Craspedia emissaria*, Walk. Cat., 22: 751 (1861); Hampson, FBI., 3 : 435 (1895).
*Dharmsala. [Moulmein; Ganjam; China; Japan].

341. *Craspedia kashmirensis*, Moore, Lep. Atk., 253 (1879-88); Hampson, FBI., 3 : 340 (1895).
*N. W. Himalayas. [Sikkim; Kandhar; China; Japan].

342. *Craspedia pedilata*, Feld., Reis. Nov., pl. 128, fifg. 1; Hampson, FBI., 3 : 431 (1895).
*Dharmsala. [Ceylon].

343. *Crocallis obliquaria*, Moore, PZS., 622 (1867); Hampson, FBI., 3 : 232. (1895).
*N. W. Himalayas. [Khasis; Japan].

344. *Cryptoloba cinerea*, Butl., AMNH., 6(5): 228; Hampson, FBI., 3: 337 (1895).
*Dharmsala. [Sikkim.]

345. *Ephyra invexata*, Walk. Cat., 26: 1497 (1862); Hampson, FBI., 3 : 445 (1895).
*Dharmsala. [Bombay; W. Ghats; Ceylon; Java].

346. *Euchloris gracilis*, Butl., Ill. Het., 7 : 104 (1889); Hampson, FBI., 3 : 498 (1895).
*Dharmsala. [Simla; Sikkim].

347. *Euchloris inductaria*, Guen. Phal., 1: 370 (1857); Hampson FBI., 3 : 499 (1895).
*Dalhousie; Dharmsala. [Nagas; E. Pegu; Borneo].

348. *Euchloris subtiliaria*, Brem., Lep. Ost-Sib., 76 (1864) Hampson FBI., 3 : 500 (1895).
*Dharmsala. [Sikkim; Niligiris; Ceylon; Japan Australia].

349. *Eupethecia atrisignis*, Butl., Ill. Het., 7 : 114 (1889); Hampson, FBI., 399 (1895).
*Dharmsala. [Khasis; Nagas; Mhow; Nilgiris; Ceylon].

350. *Eupethecia conjunctiva*, Hampson, FBI., 3 : 400 (1895).
*Dharmsala.

351. *Eupethecia fulvipennis*, Butl., Ill. Het., 7 : 114 (1889); Hampson, FBI., 3 : 400 (1895).
*Dharmsala. [Khasis].

352. *Eupethecia hemileuca*, Hampson, FBI., 3 : 401 (1895).
*Dharmsala.

353. *Eupethecia lucigera*, Butl., Ill. Het., 7 : 115 (1889); Hampson, FBI., 3 : 398 (1895).
*Dharmsala.

354. *Eupethecia rajata*, Guen. Phal., 2 : 328 (1857); Hampson, FBI., 3 : 399 (1895).
*Dharmsala. [Khasis; Nagas; Mhow; Nilgiris; Ceylon].

355. *Eupethecia subtacinta*, Hampson, FBI., 3: 399 (1895).
*Dharmsala.

356. *Garaeus absona*, Swinh., PZS., 427 (1889); Hampson, FBI., 3 235 (1895).
*Dharmsala. [Sikkim].

357. *Garaeus albipunctatus*, Hampson, FBI., 3 : 234 (1895).
*Dharmsala; Murree.

358. *Garaeus apicatus*, Moore, PZS., 617 (1867); Hampson, FBI., 3: 235 (1895).
*Murree; Dharmsala. [Sikkim].

359. *Geometra fea*, Butl., Ill. Het., 7: 106 (1889); Hampson, FBI., 3 : 497 (1895).
*Murree; Dharmsala.

360. *Gnophus cinereus*, Butl., Ill. Het., 7: 108 (1889); Hampson, FBI., 3 : 252 (1895).
*Dharmsala.

361. *Hemithea aquamarina*, Hampson, FBI., 3 : 491 (1895).
*Dharmsala. [Khasis].

362. *Hemithea graminea*, Hampson, Ill. Het., 8: 109 (1891); FBI., 3 : 491 (1895).
*Dharmsala. [Khasis; Nilgiris].

363. *Heteromiza cruentaria*, Moore, PZS. 616 (1867); Hampson FBI., 3 : 237 (1895).
*Dalhousie; Dharmsala. [Khasis].

364. *Hydrelia bicolorata*, Moore, PZS., 642 (1867); Hampson, FBI., 3 : 413 (1895).
*Dharmsala. [Sikkim; Nagas; Khasis].

365. *Hypephyra terrosa*, Butl., Ill. Het., 7 : 101 (1889); Hampson, FBI., 3 : 218 (1895).
*Dharmsala. [Simla].

366. *Larentia albofasciata*, Moore, Lep. Atk., 277; Hampson, FBI., 3: 374 (1895).
*Dharmsala. [Sikkim].

367. *Larentia consimilis*, Warr., PZS., 326 (1888); Hampson, FBI , 3 : 380 (1895)
*N. W. Himalayas. [Afghanistan].

368. *Larentia hockingii*, Butl , Ill. Het 7 : 115 (1889); Hampson, FBI., 3 : 376 (1895).
*Dharmsala. [Nagas].

369. *Larentia homophana*, Hampson, FBI., 3 : 369 (1895).
*Dalhousie. [Simla].

370. *Larentia indistincta*, Butl., Ill. Het., 7 : 118 (1889); Hampson, FBI., 3 : 369 (1895).
*Dharmsala. [Simla].

371. *Larentia schistacea*, Moore, Lep. Atk., 273; Hampson, FBI., 3 : 376 (1895).
*Dharmsala.

372. *Larentia ustipennis*, Hampson, FBI., 3 : 367 (1895).
*Dharmsala.

373. *Lithina triumbrata*, Warr., Nov. Zool., 131 (1895); Hampson, FBI., 4 : 551 (1895).
*Kashmir: Goorais valley.

374. *Loxaspilates hastigera*, Butl., Ill. Het., 7 : 112 (1889); Hampson, FBI., 3 : 182 (1895).
*Dharmsala. [Sikkim; Afghanistan].

375. *Macaria effusata*, Guen. Phal., 2 : 87 (1857); Hampson, FBI,. 3 : 206 (1895).
*Dharmsala. [Simla; Sikkim; Khasis].

376. *Macaria frugaliata*, Guen. Phal., 2 : 78 (1857); Hampson, FBI., 3 : 202 (1895).
*Dharmsala. [Karachi; Bombay; Madras Presidency; Ceylon].

377. *Macaria perfusaria*, Walk., Cat., 35, (1866); Hampson, FBI., 3 208 (1895).
*Dharmsala. [Sikkim; Khasis; Nagas; Nilgiris; Ceylon/ Rangoon; Borneo; Malaca].

378. *Medasina albidaria*, Walk. Cat., 35: 1582 (1866); Hampson, FBI., 3 : 289 (1895).
*Dharmsala. [Simla; Sikkim; Khasis].

379. *Medasina pulverulenta*, Hampson, FBI., 3 : 284 (1895).
*Dharmsala.

380. *Nemoria dispartita*, Walk. Cat., 22 : 520 (1861); Hampson, FBI., 3 : 502 (1895).
*Murree.

381. *Nemoria gelida*, Butl., Ill. Het., 7 : 104 (1889); Hampson, FBI., 3 : 502 (1895).
*Dalhousie; Kulu; Dharmsala.

382. *Nemoria indecretata*, Walk. Cat., 26:1555 (1862); Hampson, FBI., 3 : 502 (1895).
*Dharmsala. [Simla; Mhow; Nilgiris; Ceylon].

383. *Nemoria quadrinotata*, Butl., Ill. Het., 7 : 105 (1889); Hampson, FBI., 3 : 503 (1895).
*Dharmsala.

384. *Organopoda annulifera*, Butl., Ill. Het., 7 : 107 (1889); Hampson, FBI., 3 : 452 (1895).
*Dharmsala. [Khasis].

385. *Ozola microniaria*, Walk. Cat., 24 : 1080 (1862); Hampson, FBI., 3 : 328 (1895).
*Dharmsala. [Khasis; Calcutta; Ganjam; Ceylon].

386. *Percnia foraria*, Guen. Phal., 2: 217 (1857); Hampson, FBI., 3 : 307 (1895).
*Dharmsala. [Simla; Sikkim].

387. *Physetobasis dentifascia*, Hampson, FBI., 3 : 386 (1895)
*Dharmsala.

388. *Problepsis deliaria*, Guen. Phal., 2 : 13 (1857); Hampson, FBI, 3 : 462 (1895).
*Kulu. [Throughout India; Ceylon; Burma].

389. *Pseudoterpna farinosa*, Warr., PZS., 350(1893); Hampson, FBI. 3 : 480 (1895).
*Lahaul.

390. *Pseudoterpna hypoglauca*, Hampson, Trans. Ent. Soc., 313(1895); FBI., 4 : 564 (1896).
*Dalhousie.

391. *Pseudoterpna polyphaenaria*, Guen. Phal., 1:280(1857); Hampson, FBI., 3 : 477 (1895).
*Dharmsala. [Sikkim; Khasis].

392. *Pseudoterpna tephrosiaria*, Guen. Phal., 1 : 277(1857); Hampson, FBI., 3 : 473 (1895).
*N. W. Himalayas.

393. *Psyra angulifera*, Walk. Cat., 35 : 1687(1886); Hampson, FBI., 3 : 222 (1895).
*Dharmsala. [Sikkim].

394. *Psyra indica*, Butl., Ill. Het., 7 : 99(1889); Hampson, FBI., 3:222 (1895).
*Dharmasala.

395. *Rhodostrophia borealis*, Swinh., PZS., 427(1889); Hampson, FBI., 3 : 457 (1895).
*Kulu; Pangi.

396. *Rhodostrophia inconspicua*, Butl., PZS., 391(1886); Hampson, FBI., 391 (1895).
*N. W. Himalayas. [Afghanistan].

397. *Rhodostrophia palloniaria*, Guen. Phal., 2:169(1857); Hampson, FBI., 3 : 456 (1895).
*Murree. [Thandiani; Khasis].

398. *Rhodostrophia rara*, Butl., Ill. Het., 7 : 111(1889); Hampson, FBI, 3 : 456 (1895).
*Dharmsala. [Sikkim.]

399. *Rhodostrophia tristrigalis*, Butl., Ill. Het., 7:110(1889); Hampson, FBI., 3 : 456 (1895).
*Dharmsala. [Shah States.]

400. *Rhodostrophia vinacearia*, Moore, PZS., 642(1867); Hampson, FBI., 3 : 455 (1895).
*Murree. Dharmsala. [Sikkim; Khasis.]

401. *Stegania subtessellata*, Walk. Cat., 26:1648(1862); Hampson, FBI., 3 : 165 (1895).
*Dharmsala. [Khasis; Nilgiris; Canara; Borneo.]

402. *Sterrha sacraria*, Linn., Syst. Nat., 1 (2) : 863 (1766); Hampson, FBI., 3 : 424 (1895.)
*N. W. Himalayas. [Khasis; the plains of India; throughout Europe and Africa.]

403. *Synegia pluristriaria*, Walk. Cat., 26:1581(1862); Hampson, FBI , 3 : 168 (1895).
*Dharmsala. [Sikkim; Khasis; Sibsagar.]

403*a*. *Tanaorrhinus reciprocatus*, Walk. Cat., 22 : 515 (1861); Hampson, FBI., 3 : 493 (1895).
*Dharmsala. [Simla; Sikkim; Khasis; N. China;Japan.]

404. *Thalassodes glaucaria*, Walk. Cat., 35 : 1613(1866); Hampson, FBI., 3 : 509 (1895).
*Dharmsala. [Sikkim; Bhutan; Nilgiris.]

405. *Thalassodes strix*, Butl., Ill. Het., 7 :105(1889); Hampson, FBI., 3 : 509 (1895).
*Dharmsala. [Sikkim; Khasis.]

406. *Thalassodes variegata*, Butl., Ill. Het., 7:104 (1889); Hampson, FBI., 3 : 514 (1895).
*Murree; Dharmsala. [Khasis.]

406*a*. *Timandra correspondens*, Hampson, FBI., 3 : 459 (1895).
*Dharmsala.

407. *Trichopteryx viretata*, Hübn. Samml. eur. Schmett. Geom., fig. 230; Hampson, FBI., 3 : 405 (1895).
*Dharmsala. [Sikkim; Khasis; Europe.]

408. *Venilia himalayica*, Koll., Hügel's Kaschmir, 4 : 485 (1844); Hampson, FBI., 3 : 181 (1895).
*Dharmsala. [Sikkim.]

Family Pyralidae

409. *Aglossa pinguinalis*, Linn., Faun. suec., 351 (1746); Hampson, FBI., 4 : 148 (1896).
*N. W. Himalayas. [Afghanistan; Syria; Europe.]

410. *Ambia colonalis*, Brem., Lep.Ost-Sib., 67(1864); Hampson, FBI., 4 : 204 (1896).
*Dharmsala. [Amur.]

411. *Archernis tropicalis*, Walk. Cat., 18 : 670 (1859); Hampson, FBI., 4 : 379 (1896).
*Dharmsala. [Sikkim; Bombay; Nilgiris; Ceylon; Tenasserim; Formosa.]

412. *Aulacodes peribocalis*, Walk., Cat., 17 : 446 (1859); Hampson, FBI., 4 : 215 (1896).
*N. W. Himalayas. [E. Himalayas; Nilgiris; Burma; China; Aden.]

413. *Aulacodes plicatalis*, Walk. Cat., 34:1332(1865); Hampson, FBI., 4 : 214 (1896).
*Dharmsala. [Sikkim; Java; Celebes.]

414. *Aulacodes sejunctalis,* Snell., Tijd v. Ent., 19:207; Hampson, FBI., 4 : 213 (1896).
*Dharmsala. [Sikkim; Ceylon.]

415. *Bocchoris artificalis,* Led., Wien. ent.Mon., 463(1863); Hampson, FBI., 4 : 285 (1896).
*Dharmsala. [Calcutta.]

416. *Bostra subustalis,* Led., Verh. Zool.-bot. Ges. Wien., 213 (1855); Hampson, FBI., 4:285 (1896).
*Dharmsala.

417. *Botyodes patulalis,* Walk. Cat., 34 : 1405 (1865); Hampson, FBI., 4 : 327 (1896).
*Dharmsala. [Sikkim; Khasis.]

418. *Bradina translinealis,* Hampson, FBI., 4 : 228 (1896);
*N. W. Himalayas.

419. *Camptomastyx hisbonalis,* Walk. Cat., 18:707(1859); Hampson); FBI., 4 : 239 (1896).
*Dharmsala. [Simla; Khasis; Nagas; Borneo; China

420. *Cataclysta blandialis,* Walk. Cat., 17:448 (1859); Hampson, FBI. 4 : 197 (1896).
*Dharmsala. [Calcutta; Bombay; Nilgiris; Ceylon; Borneo; Amboina].

421. *Ceroprepes ophthalmicella,* Chr., Bull. Soc. Nat. Mosc.,56(1); 49; Hampson, FBI., 4: 104 (1896).
*Murree. [Amur.]

422. *Chilo pulverulentus,* Warr., AMNH., 9(6): 393; Hampson, FBI. 4 : 27 (1896).
*Dharmsala. [Khasis.]

423. *Cirrhochrista brizoalis,* Walk. Cat., 19:976(1859); Hampson, FBI., 4 : 50 (1896).
*N.W. Himalayas. [Bombay; Nilgiris; China; Japan; Formosa; Borneo; Clebes; Australia.]

424. *Coelorhyncidia ovulalis,* Hampson, FBI., 4 : 232 (1896).
*Dharmsala. [Simla].

425. *Coenodomus hockingii,* Wlsm., Trans. Linn. Soc., Zool., 5(1889); Hampson, FBI., 4 : 117 (1896).
*Kangra. [Simla; Sikkim; Calcutta; Vazigapatam; Java].

426. *Cotachena histricalis,* Walk. Cat., 18:655 (1859); Hampson, FBI., 4:142 (1896).
*Dharmsala. [Sikkim; Nagas; Nilgiris; Ceylon; China].

427. *Crambus latellus,* Snell., Trans. Ent. Soc., 644 (1890); Hampson, FBI., 4:14 (1896).
*Dharmsala. [Khasis; Nagas; Japan].

428. *Crambus nigriciliellus*, Zell., Mon. Chil. & Cramb., 52 ; Hampson, FBI., 4:17(1896).
*Dharmsala. [Bombay; China; Japan].

429. *Crambus nivellus*, Koll., Hügel's Kaschmir, 4:495 (1844); Hampson, FBI., 4:16 (1896).
*Dharmsala. [Sikkim; Nilgiris].

430. *Crambus unicolorellus*, Zell., Mon. Chil. & Cramb., 7 ; Hampson, FBI., 4:13 (1896).
*Dharmsala. Punjab: Meean Mir; [Nilgiris].

431. *Cryptoblabes bipunctalis*, Hampson, FBI., 4:105 (1896).
*Dharmsala.

432. *Diasemia accalis*, Walk. Cat., 19:1015 (1859); Hampson, FBI., 4:411 (1896).
*Dharmsala. [Burma; Shanghai].

433. *Diathrausta picata*, Butl., Ill. Het., 7:94 (1889); Hampson FBI., 4:234 (1896).
*Dharmsala.

434. *Dichocrocis definita*, Butl., Ill. Het., 7:97 (1889); Hampson, FBI., 4:308 (1896).
*Dharmsala. [Sikkim; Khasis].

435. *Dichocrocis nigrilinealis*, Walk. Cat., 34:1410 (1865); Hampson, FBI., 4:308 (1896).
*Dharmsala. [Sikkim; Khasis; Bombay; Nilgiris; Lower Burma; Ceylon; Combodia; Sula; Celebes; Mysol].

436. *Diptychophora adspersella*, Snell., Tijid. v. Ent., 61 (1893); Hampson, FBI., 4:19 (1896);
*Dharmasala. [Ceylon].

437. *Diptychophora minutalis*, Hampson, FBI., 4:18 (1896).
*Dharmsala. [Sikkim; Bhutan; Ceylon].

438. *Endotricha fuscifusalis*, Hampson, FBI., 4:134 (1896).
*Dalhousie.

439. *Endotricha sondaicalis*, Snell., Tjid. v. Ent., 23:200 (188) ; Hampson, FBI., 4:135 (1896).
*Dharmsala. [Sikkim; Celebes].

440. *Epicrocis festivella*, Zell., Isis, 878 (1848); Hampson, FBI., 4:87 (1896).
*Dharmsala. [Ceylon; Java; S. Africa].

441. *Epicrocis hilarella*, Rag., Nouv. Gen., 22; Hampson, FBI., 4:87 (1896).
*Murree. [Simla; Ceylon; China].

442. *Glyphodes perspectalis*, Walk. Cat., 18:515 (1859); Hampson, FBI., 4:353 (1896).
*Dharmsala. [China; Japan].

443. *Heliothela ophideresana*, Walk. Cat., 28:459 (1896); Hampson, FBI., 4:446 (1896).
*Dharmsala. [Ceylon; Madagascar; Australia].

444. *Hemiscopis expansa*, Warr., AMNH., 9 (6):396; Hampson, FBI., 4:417 (1896).
*Dharmsala. [Simla].

445. *Hendecasis duplifascialis*, Hampson, Ill., Het., 8:141(1891); Hampson. FBI., 4:140 (1896).
*Dharmsala. [Nilgiris; Ceylon; W. Africa].

446. *Herculia dharmsalae*, Butl., Ill. Het., 7:92 (1889); Hampson. FBI., 4:162 (1896).
*Dharmsala.

447. *Homoeosoma griseipennella*, Hampson, FBI., 4:67 (1896).
*Murree.

448. *Hypsipyla robusta*, Moore, Lep. Ceyl., 3:365; Hampson, FBI., 4:89 (1896).
*Dharmsala. [Simla; Sikkim; Ceylon].

449. *Larice phycidalis*, Guen. Delt. & Pyr., 121 (1854); Hampson, FBI., 4:158 (1896).
*Kulu. [E. Pegu].

450. *Leucinodes apicalis*, Hampson, FBI., 4:371 (1896).
*Dharmsala. [Ceylon].

451. *Marasmia trebiusalis*, Walk. Cat., 18:718 (1859); Hampson, FBI., 4:276 (1896).
*Dharmsala. [Ceylon; Borneo; Flores; W. Africa].

452. *Mesolia pandavella*, Rag., Ann. Soc. Ent. France, 282 (1888); Hampson, FBI., 4:31 (1886).
*Dharmsala. [Lahore; Trichinopoly; Ceylon].

453. *Mixophila renatusalis*, Walk. Cat., 17:484 (1859); Hampson, FBI., 4:190 (1896).
*Dharmsala. [Bhutan; Ceylon; Shan States; Borneo; Java; Sambawa; New Guinea].

454. *Nacoleia commixta*, Butl., AMNH., 4(5): 453; Hampson, FBI., 4:322 (1896).
*Dharmsala. [Nagas; Nilgiris; Ceylon; Japan].

455. *Nacoleia cyanealis*, Walk. Cat., 17:405 (1895); Hampson, FBI., 4:321 (1896).
*Kulu. [Nilgiris; Ceylon; Shan States; Borneo; Japan].

456 *Nacoleia major,* Butl., Ill. Het., 7:96 (1889); Hampson, FBI., 4:319 (1896).
*Dharmsala. [Sikkim; Khasis].

457. *Nacoleia marionalis,* Walk. Cat., 19:930 (1859); Hampson, FBI., 4:321 (1896).
*Dharmsala. [Borneo; Burma; Sikkim].

458. *Nacoleia ossea,* Butl., Ill. Het., 7:96 (1889); Hampson, FBI., 4:319 (1896).
*Dharmsala.

459. *Nephopteryx rhyparella,* Rag., Nouv. Gen., 15; Hampson, FBI., 4:77 (1896).
*Murree. [Campbellpur; Simla].

460. *Noctuelia floralis,* Hübn., Samml. eur. Schmett., Pyr., fig. 142; Hampson, FBI., 4:445 (1896).
*N. W. Himalayas. [Punjab ; Sind; Bombay; Afghanistan; Yarkand; Syria; Europe].

461. *Noctuelia fuscinervis,* Hampson, FBI., 4 : 445 (1896).
*Murree.

462. *Oligostigma bilineale,* Snell., Tijid. v. Ent., 19 : 196; Hampson, FBI., 4 : 208 (1896).
*Dharmsala. [Calcutta].

463. *Parthenodes vagalis,* Walk. Cat., 34 : 1530 (1865); Hampson, FBI., 4 : 219 (1896).
*Dharmsala. [Punjab; Nilgiris; Java].

464. *Phycita obliquifasciella,* Hampson, FBI., 4 : 93 (1896).
*Dharmsala.

465. *Pionea aureolalis,* Led., Wien. ent. Mon., 473 (1863); Hampson, FBI., 4 : 424 (1896).
*Dharmsala. [Sikkim; Khasis; Ceylon; Andamans.]

466. *Pionea brevialis,* Walk. Cat., 18 : 660 (1859); Hampson, FBI., 4 : 426 (1896).
*Dharmsala. [Nagas; Nilgiris; Ceylon; Jones Islands, N. Australia].

467. *Pionea mandronalis,* Walk. cat., 19 : 1014 (1859); Hampson, FBI., 4 : 23 (1896).
*Dharmsala. [Ceylon].

468. *Pionea verbascalis,* Schiff., Wien. Verz., p. 121 (1776); Hampson, FBI., 4 : 423 (1896).
*Dharmsala. [Sikkim; Nilgiris; Europe].

469. *Platytes albipennella,* Hampson, PZS., 946 (1895); FBI., 4 : 21 (1896).
*Murree.

470. *Platytes interstriatella*, Hampson, PZS., 945 (1895) FBI., 4 : 22 (1896).
*Dharmsala.

471. *Platytes marginipunctalis*, Hampson, PZS., 945 (1895); FBI., 4 : 20 (1896).
*Dharmsala.

472. *Platytes strigulalis*, Hampson, PZS., 946 (1895); Hampson, FBI., 4 : 21 (1896).
*Murree. [Punjab: Meean Mir; Nagas; Ceylon].

473. *Polyocha aurifusella*, Walk. Cat., 35 : 1756 (1866); Hampson, F5I., 4 : 61 (1896).
*N. W. Himalayas. [Punjab; Bombay].

474. *Polyocha depressella*. Swinh., PZS., 876 (1885); Hampson, FBI., 4 : 63 (1896).
*Dharmsala. [Poona; Nilgiris; Pulo Laut].

475. *Polyocha detritella*, Rag., Nouv. Gen., 39; Hampson, FBI., 4 : 63 (1896).
*Dharmsala.

476. *Polyocha leucania*, Feld., Reis. Nov., pl. 137, fig. 1 Hampson 3; FBI., 4 : 63 (1896).
*Dharmsala. [Sikkim; Nilgiris; Ceylon; Burma].

477. *Poujadia ochridorsella*, Raj., Nouv. Gen., 42; Hampson, FBI., 4:58 (1896).
*Dharmsala [Ceylon].

478. *Poujadia sepicostella*, Rag., Nouv. Gen., 42; Hampson, FBI., 4 : 58 (1896).
*N. W. Himalayas. [Punjab].

479. *Pycnarmon jaguaralis*, Guen., Delt. & Pyr., 283 (1854);Hampson, FBI., 4 : 256 (1896).
*Dharmsala. [Sikkim; Assam; Malaca; Celebes; Mysol; Waigion; New Guinea; Solomons].

480. *Pycnarmon lactiferalis*, Walk. Cat., 17 : 480 (1859); Hampson, FBI., 4 : 259 (1896).
*N. W. Himalayas. [E. Himalayas; Ceylon; Burma; Pulo Laut; Borneo; Celebes; China; Japan].

481. *Pyralis fumipennis*, Butl., Ill. Het., 7: 91 (1889); Hampson, FBI., 4 : 151 (1896).
*Dharmsala. [Simla; Ceylon].

482. *Pyralis pictalis*, Curt., Br. Ent., 6, pl. 503; Hampson, FBI., 4 : 150 (1896).
*N. W. Himalayas. [Nagas; Ceylon; Burma; Sumatra; Gilbert Isl., ; Japan; W. Africa; Europe].

483. *Pyralis recisalis*, Swinh., PZS., 866 (1885); Hampson, FBI., 4 : 149 (1896).
*Dharmsala. [Bombay].

484. *Pyralis regalis*, Schiff., Wien. Verz., 124 (1776);Hampson, FBI., 4 : 152 (1896).
*Dharmsala. [Japan; Amur; S. Europe].

485. *Pyrausta bisignata*, Butl., Ill. Het., 7 : 98 (1889); Hampson, FBI., 4 : 440 (1896).
*Dharmsala. [Simla].

486. *Pyrausta cespitalis*, Schiff., Wien.. Verz., 123 (1776); Hampson, FBI., 4 : 430 (1896).
*Dharmsala. [Afghanistan, Punjab;Bermardmyo; Syria Europe; Siberia].

487. *Pyrausta citrinalis*, Warr., AMNH., 9 (6) : 302; Hampson, FBI., 4 : 442 (1896).
*Dharmsala.

488. *Pyrausta damoalis*, Walk. Cat.,. 18 : 656 (1859); Hampson, Dharmsala. [Sikkim; Rangoon; China; Japan].

489. *Pyrausta dimiasalis*, Wlk., Wlk., Cat., 18: 649 (1859); Hampson, FBI, 4 : 442 (1896).
*Dharmsala. [Shanghai].

490. *Pyrausta indistans*, Moore, Lep. Atk., 223; Hampson, FBI., 2: 438 (1896).
*Dharmsala. [Sikkim.]

491. *Pyrausta sikkima*, Moore, Lep. Atk., 207; Hampson, FBI., 4: 430 (1896).
*Dharmsala. [Sikkim; Nagas; Andamans].

492. *Pyrausta silhetalis*, Guen., Delt & Pyr., 166 (1854); Hampson, FBI, 4 : 429 (1896).
*N. W. Himalayas. [E. Himalayas; Khasis; Yarkand.]

493. *Rhimphalea trogusalis*, Wlk., Wlk., Cat., 18: 711 (1859); Hampson, FBI, 4 : 278 (1896).
*Dharmsala. [Sikkim; Khasis; Andamans ; Manila; Borneo; Celebes].

494. *Schenobius immeritalis* Walk. Walk. Cat., 19 : 830 (1859); Hampson FBI 4 : 47 (1896).
*Dharmsala; [Calcutta; Ceylon; Siam.]

495. *Scirpophaga cramboides* Walk. Walk., Cat., 31 : 230 (1864); Hampson FBI, 4 : 47 (1896).
*Dharmsala. [Simla.]

496. *Scoparia mediorufalis* Hampson, FBI, 4 : 243 (1896)
*Dharmsala. [Sikkim.]

497. *Scoparia murificalis* Walk. Walk. Cat., 19 : 836 (1859); Hampson FBI, 4 : 244 (1896).
*Dharmsala. [Ceylon; Simla.]

498. *Simaethistis tricolor* Butl., Ill. Het., 7 : 95 (1889); Hampson, FBI, 4 : 447 (1896).
*Dharmsala. [Khasis.]

499. *Stemmatophora laticincta* Hamp., FBI, 4 : 157 (1896)
*Dharmsala.

500. *Stemmatophora monostaechalis* Warr., AMNH., 7(6): 497; Hampson, FBI, 4 : 157 (1896).
*Dharmsala.

501. *Stenia punctalis* Schiff., Wien. Verz., 123 (1776); Hampson, FBI, 4 : 234 (1896).
*Dharmsala. [Armenia; Europe.]

502. *Sylepta bipunctalis* Warr., PZS., 333 (1888); Hampson, FBI, 4: 332 (1896).
*Dharmsala. [Thandiani.]

503. *Sylepta deficiens* Moore, Lep. Ceyl., 3 : 556; Hampson, FBI, 4 : 337 (1896).
*Dharmsala. [Sikkim; Ceylon].

504. *Sylepta luctuosalis* Guen., Delt, & Pyr., 290 (1854); Hampson, FBI, 4 : 340 (1896).
*N. W. Himalayas. [E. Himalaya; Andamans; Borneo; China; Japan; Siberia.]

505. *Sylepta sabinusalis* Wlk., Wlk. Cat., 18 : 708 (1859); Hampson, FBI, 4 : 333 (1896).
*N. W. Himalaya. [E. Himalaya; Khasis; Karachi; Bombay; Nilgiris; Ceylon; Borneo; Java; Celebes; Sumbawa; New Britain; Solomons; Fiji.]

506. *Talanga sexpunctalis* Moore, PZS, 661 (1877); Hampson, FBI:, 4:221 (1896).
*Dharmsala. [Sikkim; Bombay; Nilgiris; Ceylon; Andamans; Borneo; Celebes; Formosa; New Britain; New Hebrides.]

507. *Terastia egialealis* Wlk., Wlk. Cat., 17 : 383 (1889); Hampson, FBI, 4 : 381 (1896).
*Dharmsala. [Sikkim; Java.]

508. *Thliptoceras cascale* Swinh., Trans. ent. Soc., 271 (1890);Hampson, FBI, 4 : 371 (1896).
*Dharmsala. [Sikkim; Bombay; Nilgiris; Ceylon; Rangoon; Japan.]

509. *Typasodes linealis* Moore, PZS, 665 (1867); Hampson, FBI, 4 : 298 (1896).
*Dharmsala. [Sikkim; Ceylon; Andamans.]

510. *Tyspanodes venosa* Butl., Ill. Het., 7 : 98 (1889); Hampson, FBI, 4 : 299 (1896).
*Dharmsala. [Sikkim; Java.]

ADDITIONAL NOTES

Family Papilionidae

1. *Papilio machaon ladakensis* (Moore), Talbot, 1 : 196 (1939); Contribution No. 65, 700 (1955).
*Ladak; Sutlej Valley, Parbati valley; Manali; Hamta.

2. *Parnassius charltonius charltonius* Gray., in Talbot, 1 : 298 (1939); Contribution No. 65 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

3. *Parnassius jacquemontii jacquemontii* (Boisd), Talbot, FBI, 1 : 265 (1939); Contribution No. 65 : 701 (1955).
*Parbati Valley; Sutlej Valley; Manali; Hamta.

4. *Parnassius stoliczkanus* Felder, Talbot, FBI, 1 : 272 (1939) Contribution No. 65, 701, (1955).
*Shirangla, 18,000 ft; Sutlej Valley; Parbati Valley; Manali; Hamta.

5. *Parnassius stoliczkanus spitiensis* Bang-Hass, in Talbot, FBI, 1 : 276 (1939).
*Sutlej Valley; Parbati Valley; Hamta; Manali.

Family Pieridae

6. *Aporia nebellica nebellica* (Boisdl.), in Talbot, FBI, 1 : 315 (1939); Contribution No. 65, 702 (1955).
*Kashmir; Sutlej Valley.

7. *Baltia butleri butleri* (Moore), Talbot, FBI, 1 : 309 (1939) Contribution No. 65, 702 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

8. *Pontia chloridice alpina* (Verity), Talbot, FBI, 1 : 433 (1939) Contribution No. 65, 703 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

9. *Pieris deota* (de Niceville), Talbot, FBI, 1 : 424 (1939); Contribution No. 65, 703 (1955).
*Gartok.

10. *Colias eogene* Felder, Talbot, FBI, 1 : 555 (1939); Contribution No. 65, 703 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

11. *Colias ladakensis*, Felder, Talbot, FBI, 1 : 548 (1939); Contribution No. 65 : 703 (1955).
*Sutlej Valley; Parbati Valley; Mandi; Hamta.

Family Nymphalidae

12. *Aulocera brahminus* (Blanchard), Bingham, FBI, 1 : 126 (1905); Contribution No. 65; 704 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

13. *Erebia kalinda* Moore, Bingham, FBI, 1 : 149 (1905) Contribution No. 65 : 705 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

14. *Liminitis trivena* Moore, Bingham, FBI, 1 : 297 (1905) .
*N. W. Himalya, 12,000 ft.

15. *Maniola davendra* Moore, Bingham, FBI, 1 : 119 (1905); Contribution No. 65, 706 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

16. *Nytha baldiva* Moore, Bingham, FBI, 1 : 114 (1905) Contribution No. 65, 707 (1955).
*Ladak; Parbati Valley; Sutlej Valley; Manali; Hamta. [Hunza; Chitral].

17. *Vanessa ladakensis*, Moore, Bingham, FBI, 1 : 368 (1905); Contribution No. 65, 708 (1955).
*Sutlej valley, Parbati Valley; Manali; Hamta;

Family Lycaenidae

18. *Lycaena hylas* (Wiener), Bingham, FBI, 2 : 351 (1907); Contribution No. 65, 708 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

19. *Lycaena omphisa* Moore, Bingham, FBI, 2 : 347 (1907); Contribution No. 65, 709 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

20. *Lycaena pheretes lehana* Moore, Bingham, FBI, 2 : 352 (1907) Contribution No. 65, 709 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

21. *Lycaena stoliczkana* Felder, Bingham, FBI, 2 : 341 (1907); Contribution No. 65, 709 (1955).
*Sutlej Valley; Parbati Valley; Manali; Hamta.

HYMENOPTERA

By V. K. GUPTA

Superfamily Tenthredinoidea

Family Tenthredinidae

1. *Allantus himalayensis* Radoszkovsky, *in* Malaise, RIM, 36 (4): 458 (1934).
*Kashmir : Killanmarg, 10,500 ft. [Simla Hills: Kufri, Phagu, 8000-9000 ft. Dehra Dun : Chakrata].

2. *Allantus kashmirica* Malaise, RIM. 36 (4) : 464 (1934).
*Kashmir.

3. *Athalia leucostoma* Cameron, JBNHS, 17 : 289 (1906).
*Kashmir.

4. *Dosytheus kashmirensis* Cameron, JBNHS, 17 : 290 (1906).
*Kashmir, 5000-6000 ft.

5. *Laurentia punjabica* Malaise, RIM, 36 (4) : 465 (1934).
*Dharmsala, 5000 ft. [Simla Hills; Phagu; Kufri, 8000-9000 ft.]

6. *Rhogogastra bituberculata* Cameron, JBNHS, 17 : 289 (1906).
*Kashmir, 6000 ft.

Superfamily Siricoidea

7. *Paururus javencus* (Linnaeus), *in* Malaise, RIM, 36 (4): 474 (1934).
*Murree: Kohala, 2000 ft.

Supeframily Ichneumonoidea

Family Braconidae

8. *Apanteles ruidus* Wilkinson, Bull. Ent. Res., 19 : 94 (1928); Gupta, Agra Univ. J. Res., 4 : 753 (1955).
*Kulu Valley : Katrain, 5500 ft. [Dehra Dun; Rohatgoan (Hoshangabad)].

Superfamily Sphecoidea

Family Sphecidae

9. *Ammophila laeta* Bingham, FBI, 1 : 234 (1897); Gupta, Agra Univ. J. Res., 4 : 754 (1955).
*Lahoul-Spiti Valley : Gramphu, 12, 000 ft., Dhorni, 12,000 ft.; Hamta Gorge, 12,000 ft., Kulu Valley: Manali, 6000 ft. [Afganistan: Chaman.]

10. *Arpactus (Hoplisoides) remotus* Turner, Mem. Dept. Agric., India, Ent. Ser., 5 (4) : 182 (1917).
*Jammu.

Family Crabronidae

11. *Crabro adrens* Cameron, Manch. Mem., (4) 3 : 270 (1890); Gupta Agra Univ. J. Res., 4 : 754 (1955).
*Rahla, 9000 ft. [Bombay, Barrackpore.]

12. *Crabro (Clytochrysus) sexcinctus* Fabricius, *in* Turner, Mem. Dept. Agri. India, Ent. Ser., 5 (4) : 189 (1917).
*Kashmir: Gulmarg. [Europe; W. Asia; Hazara Distt., 8000 ft.]

13. *Crabro* sp., Gupta, Agra Univ. J. Res., 4 : 755 (1955) Rahla, 9000 ft.

14. *Rhopalum iridescens* Turner, Mem. Dept. Agri. India, Ent. Ser., 5 (4) : 187 (1917).
*Kashmir: Gulmarg.

Superfamily Vespoidea

Family Vespidae

15. *Vespa velutina* Lepel, Lepel Hymen., 1 : 507; Bingham FBI, 1 : 405 (1897); Gupta, Agra Univ. J. Res., 4 : 755 (1955).
*Kulu Valley : Marhi, 12,000 ft. Lahoul-Spiti Valley: Dhorni, 12,000 ft. Hamta Gorge, 12,000 ft. [Kumaon; Sikkim; Burma; Tenasserim; China, Java.]

Family Eumenidae

16. *Odynerus punctatum* (Fabricius), Syst. Piez., p. 273 (1804) (*Polistes*); Bingham, FBI, 1 : 365 (1897); Gupta, Agra Univ. J. Res., 4 : 755 (1955).
*Kulu Valley: Katrain, 5500 ft. [Barrakpore; Allahabad; Bombay; Bangalore.]

17. *Odynerus* sp., Gupta, Agra Univ. J. Res. 4 : 756 (1955).
*Kulu Valley : Manali, 6000 ft; Katrain, 5500 ft.

Family Psammocharidae

18. *Pompilus ariadne* Cameron (?), Maneh. Mem. (4) 4 - 457 (1891); Bingham, FBI, 1 : 159 (1897); Gupta, Agra Univ. J. Res. 4 : 756 (1955).
*Kulu Valley : Rahla, 9000 ft. [Barrakpore; Tenasserim]

Superfamily Apoidea

Family Xylocopidae

19. *Xylocopa bentoni* Cockerell, Proc. U. S. Nat. Mus., 55 : 172 (1219); Maa, RIM, 40 : 293 (1938).
*Dharmsala, 4800 ft; Kaisdhar, 8500 ft;
*Kulu. [Abbottabad; Hindu Kush, Afganistan; Mossy Falls, Mussooric; Dehra Dun; Ranikhet; Garhwal; Almora; Chakrata; Kumpon.]

20. *Xylocopa fanestrata* (Fabricius), Entom. Syst. Suppl. p. 273 (1798) (*Apis*); Bingham, FBI, 1 : 539(1897); Maa, RIM, 40 : 285 (1938).
*Kashmir : Srinagar, Chashma Shahi; Ramban-Udampur Distt. Kangra Valley. [Baluchistan; Pansni; Rawalpindi; Delhi; Karachi; Bombay; Bijnor; Nainital; Dehra Dun; Bangalore; Madras; Darjeeling; Persia; Burma; Ceylon and Celebes.]

21. *Xylocopa leucothorax* (de Geer), Mem. Hist. Insect, 3 : 573(1773) (*Apis*); Maa, RIM, 40: 307 (1938).
*Kangra : Shahpur, 4500 ft. [Baluchistan; Punjab; U. P.; Bombay; Sind; Goa; Madras.]

22. *Xylocopa nasalis aruipennis* Lepeletier, Hist. Nat. Insect, Hymen, 2:181 (1841) (*X. auripennis*); Maa, RIM, 40:279 (1938). *Kashmir : Chashma Shahi; Srinagar. [U. P.;M.P.; Bombay; Travancore; Bangalore; Coimbatore; Calcutta; Burma; Assam; Sikkim; Ceylon; China.]

23. *Xylocopa punctigena* Maa, RIM, 40 : 291 (1938). *Punjab: Hamirpur Range. [Hoshiarpur; Mussoorie; Bhadraj, 500 ft.]

24. *Xylocopa tenuiscapa* Westw., *in* FBI, 1 : 537(1897); Maa, RIM, 40 : 321 (1938).

*Kashmir: Chashma Shahi, Srinagar. [Dehra Dun, Saharanpur; Kumaon; Nagpur; Bombay; Goa; Mysore; Travancore; Kodaikanal; Chilka Lake; Nallamalai Hills.]

25. *Xylocopa valga* Gerstaeker, Entom. Zeitung. Stettin., p. 276(1872); Maa, RIM; 40 : 283 (1938).

*Kashmir : Jhelum Valley, 5200 ft; Srinagar; Haran Plateau, 5000 ft. ; Gilgit; Sind Valley; Chamba : Sarol Garden; Punjab : Shahpur. [NWFP; Asia minor; U.S.S.R.; Turkestan; China; and Palaearctic region].

26. *Xylocopa verticalis* Lepel., Hist. Nat. Insect, Hymen., 2 : 195(1841); Bingham, FBI, 1 : 541(1897); Maa, RIM, 40 : 315 (1938).

*Kashmir (?) : Chashma Shahi, Srinagar. [Madras; Orissa; Bihar; Bengal : Calcutta, Murshidabad; Sikkim; Malaya : Kwala Kangsar, Perak; Sumatra : Medan]

Family Bombidae

27. *Bombus atrocinctus terminalis* Smith, Trans. Zool. Soc., 7 : 197 (*B. atrocinctus*); Frison, RIM, 37 : 360 (1935) (*Bremus*)

*Dharmsala, 5500 ft; Shahpur, Kangra Valley, 4500 ft [Sikkim, 10,000 ft; Garhwal; Kumaon; Almora, W. Himalaya, 11,000 ft. Tibet, 14,000 ft; Throughout China.]

28. *Bombus festivus* Smith, J. Ent., 1 : 152 (1861); Bingham, FBI 1 : 553 (1897); Frison, RIM, 37 : 356 (1935)(*Bremus*) *Chamba. [Kumaon; Almora; Nainital; Sikkim, 6000 ft; China.]

29. *Bombus funerarius binghami* Gupta, Agra Univ. J. Res., 4 : 757 (1955).

*Srinagar. [Chakrata; Sikkim, 8000 ft.]

30. *Bombus haemorrhoidalis* Smith, Trans. ent. Soc., 2 : 43 (1852); Gupta, Agra Univ. J. Res., 4 : 757 (1955).
*Ladak : Dras, Kargil, Leh; Kangra Valley, 4500 ft; Shahpur; Chamba; Kashmir : Srinagar, 6000 ft. [Kumaon; Nainial; Mussoorie; Almorah; Garhwal; Simla Hills. West Himalaya, 7000 ft.]

31. *Bombus melanurus subdistinctus* Richards, *in* Frison, RIM, 37: 341 (1935).
*Pangkong Valley, Leh.

32. *Bombus mimeticus insidiosus* Richards, in Frison, RIM, 37 : 348 (1935).
*Kangra Valley Dharmsala. [Mussoorie; Saraiya Tal Garhwal; Simla Hills; Kasauli; Kumaon.]

33. *Bombus rotundiceps protensus* (Frison), RIM, 37 : 361 (1935) (*Bremus*).
*Shahpur. [W. Himalayas : Kumaon; Dharampur, 5000 ft.]

34. *Bombus rufofasciatus* Smith, Trans. ent. Soc., 2 : 48 (1852); Bingham FBI, 1 : 547 (1897); Gupta, Agra Univ. J. Res., 4: 756 (1955).
*Lahoul-Spiti Valley : Chhatru, 12,000 ft; Namu, 10,000 ft. [Northern India; Sikkim, 12, 000 ft.]

35. *Bombus simillimus* Smith, Trans. ent. Soc., 2 : 48 (1852) Bingham, FBI, 1 : 554 (1897); Gupta, Agra Univ. J. Res., 4 : 757 (1955).
*Manali, 6000 ft. [Northern India; China.]

36. *Bombus tunicatus* Smith, Trans. ent. Soc., 2: 43 (1852); Bingham, FBI, 1 : 549 (1897); Frison, RIM, 37 : 350 (1935) (*Bremus*).
*Chamba; Dalhousie, 7000 ft; Gilgit. [Mussoorie; Garhwal; NWFP; Simla].

Additional distributions of *Bombus* species recorded in First Check-List.

1. *Bombus longiceps* Smith, —Kashmir.
2. *Bombus melanurus* Lepel., —Manali, 6000 ft.

Order DIPTERA

By SANTOKH SINGH

Orthorrhapha

Family Deuterophlebiidae

1. *Deuterophlebia mirabilis*, Edwards Ann. Mag. Nat. Hist., 9: 39 (1922; Pulikovsky, N., Tran. Ent. Soc. London, p. 45, (1924)
*Kashmir. [Altai mountains.]

Family Blepharoceridae

2. *Euliponeura horai*, Tonnoir, RIM, 32 (2) : 176 (1930).
*Dalhousie (Punjab).

3. *Horai* sp., Tonnoir, RIM., 32 (2) : 193 (1930).
*Chamba (Punjab).

Family Tabanidae

4. *Chrysops designatus*, Ricardo, RIM., 4 : 383-384 (1911).
*Kashmir : Gandarbal. [Nepal; Mohand (U. P).; Yunan; Assam; Jaulasal (Nainital Distt. U. P.].

5. *Tabanus excelsus*, Ricardo, A. M. N. H., 8 (11) : 543 (1913).
*Kangra Distt. [U. P. Mashobra, Mohand, Dehra Dun].

6. *Tabanus leleani*, Austen., Aust. Bull. Entom. Res., 10: 312-316, figs. 13-14 (1920).
*Srinagar; Kangra Valley. [Attock; Quetta; Seistan].

7. *Tabanus macer*, (Bigot.), Mem. Soc. Zool. Fr., 5 : 649 (1892), (*Atylotus*).
*Murree; Chamba state. [Jhelum Distt., Pathankot, Rawalpindi; Kathgodam, Mohand; South India: Trichinopoly, Coimbatore, Taliparamba; Nagpur, Dharwar; Goa; Pusa].

8. *Tabanus orientis*, Walker, List Dipt. B. M., 1 : 152 (1848).
*Murree : Dongagalli; Kangra Distt; Dalhousie. [Punjab : Jhelum Distt; U.P. ; Nainital, Massoorie, Muktesar, Mohand, Thandiani;Nepal;Western Bhutan; Sikkim; Yunan.]

9. *Tabanus rubidus*, Wied., Dipt. Exot., 6 9 (1821).
*Kangra, Dharmsala; Kashmir.
[Punjab : Jhelum Distt., Rawalpindi, Dehra Ismail Khan; U.P.; Partabgarh, Massoorie, Muktesar; Bihar; Assam; Bengal; Bombay; W. Ghats; S.Kanara; Ceylon;

Upper Burma; Java; Sumatra; Siam; Hong Kong; Cochin China; Annam].

10. *Tabanus subcallosus*, (Ricardo), RIM., 4 : 227-228), (1911) (*Therioplectes*).
*Kangra ; Dalhousie, Donera. [Mussoorie, Muktesar, Dehra Dun, Dogaon, Meerut, Muzaffarnagar.]

11. *Tabanus virgo*, Wiedemann, Anal. Ent., 22 (1824).
*Kangra, Kotla. [Madras; Mysore; Calcutta; Pusa; Mohand (U.P.); Bihar: Chapra, Hazaribagh; Rawalpindi; Bareilly; Cuttack.]

Family Bombyliidae

12. *Bambylius major*, L. Syst. Nat. edn., 10: 606 (1758).
*Murree Hills. [Simla Distt; N. America; Europe; N. Africa; Japan].

Family Asilidae

13. *Cyrtopogon laxenecera*, Bromley, RIM, 37 (2) : 228, (1935).
*Bakrota Hill, Dalhousie 7000 ft.

14. *Machimus inutilis*, Bromley, RIM., 37 (2) : 222, (1935).
*Bakrota Hill, Dalhousie 7000 ft.

15. *Machimus subgenitalis*, Bromley, RIM, 37 (2): 221 (1935).
*Bakrota Hill, Dalhousie 7000 ft.

16. *Machimus* (*Tolnerus*) *punjabensis*, Bromley, RIM., 37 (2) : 220 (1935).
*Kangra Valley : Ninnu Khad at Baijnath, 3000 ft.

17. *Stenopogon subtus*, Bromley, RIM., 37 (2) : 229 (1935).
*Dayankund Nallah, on Dalhousie-Khajiar road, 8000 ft.

Cyclorrhapha

Family Trypetidae

18. *Vidalia cervicornis*, Brunetti, RIM., 13 : 95 (1917).
*Murree. [Phagu].

Family Nycteribiidae

19. *Nycteribia* (*Lestropodia*) *pedicularia*, Latr. Scott, H., RIM., 27 (5) : 354 (1925).
*Kashmir. [Darjeeling; Europe; N. Africa; China; Formosa; S. Africa].

20. *Penicillidia dufouri*, (Westw.), Scott., H., RIM., 27(5): 353 (1935).
*North West Himalayas: Kashmir.
[East Himalayas; Europe; N. Africa; Formosa].

THE HEART AND ITS CONDUCTING SYSTEM IN ALBINO RATS*

By RAVI PRAKASH, M. SC., PH. D., D. SC., F. A. Z.; *Professor and Head of the Department of Zoology, Government Hamidia College, Bhopal.*

The present investigation on the heart of albino rats was carried out for ascertaining whether the neurogenic or the myogenic theory of conduction of stimuli for contraction is supported by the histological structure of the heart and conducting tissue.

The supporters of the neurogenic theory maintain that in the heart of vertebrates nerve elements are responsible for initiating and conducting the stimulus for contraction. Tawara (22) showed that in the heart of calf the bundle of His, which conducts the atrial stimulus of contraction to the ventricles, is accompanied by a fairly prominent nerve bundle. Retzer (21) observed a plexus of non-medullated nerves surrounding the Purkinje fibres and regarded them as important constituents of the impulse conducting tissue. Wilson (24) described an intricate nerve pathway in the atrioventricular bundle (bundle of His) for conveying the contraction stimulus from atria to ventricles. Woolard (25) studied in detail the distribution of vagus and sympathetic fibres of the heart. Nonidez (14) showed that the sinuatrial node (pace maker), which is the site of the initiation of the cardiac impulse, the atrioventricular node, which controls the transmission of the rhythmic impulses through the atrioventricular groove and the atrioventricular bundle are all supplied by cholinergic (vagal) nerve fibres. Baird and Robb (1), in their studies on the heart of dog, observed nerve cells and ganglia in the interatrial septum and also just anterior to the atrioventricular groove in the dorsal and ventral portions of the septum.

From among the supporters of the myogenic theory, some believe in the presence of only simple muscular connexions, while others have demonstrated the existence of histologically specialized structures at the junction of the various chambers of the heart for initiating and conducting the cardiac stimulus of contraction. Haller (7), who is known as the father of myogenic theory, believed that the impulse formation and transmission of the heart are due to the inherent irritability of the myocardial cells. Kent (11) studied the heart of several new-born and adult mammals and pointed out that the musculature of the atria is not separated from that of the ventricles but is intimately connected with it. He showed that in mammals the transmission of the contraction impulse from atria to ventricles is a case of simple muscular conduction. Purkinje (20) observed a number of pale multinucleated fibres beneath the endocardium in the ventricles of the heart of mammals. His (8) demonstrated the presence of an atrioventricular bundle at the atrioventricular junction of the heart of mammals. Keith and Flack (10) Kistin (12) and Prakash (16-19) have also supported the myogenic theory of cardiac conduction. These authors have not only demonstrated the existence of a histologically specialized impulse conducting tissue but have also emphasized that the atrial stimulus of contraction could be transmitted to the ventricles only through the muscular atrioventricular bundle. They did not find either the multiple atrioventricular connexions of Kent (11) or the accessory pathways for the conduction of the contraction impulse of Davies (3). Prakash (16) further maintains that the presence of accessory connexions other than those through the bundle of His, would be responsible for premature excitation of the ventricle. Some recent investigators (6) not only support the neurogenic theory but very strongly criticize the myogenic theory. They believe that there does not exist in the heart of mammals a sinuatrial node, an atrioventricular node or an atrioventricular bundle and therefore conclude, "until it is proved that the nerve cells within the heart do not originate the cardiac impulse and that the impulse is not carried by the fibres of these cells to the individual units of the myocardium, it is folly and waste of mental energy to develop theory upon theory to explain impulse formation and conduction on the basis of a nonexistent muscular conduction system."

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*Contribution No. 13 from Vigyan Mandir, Bhopal.

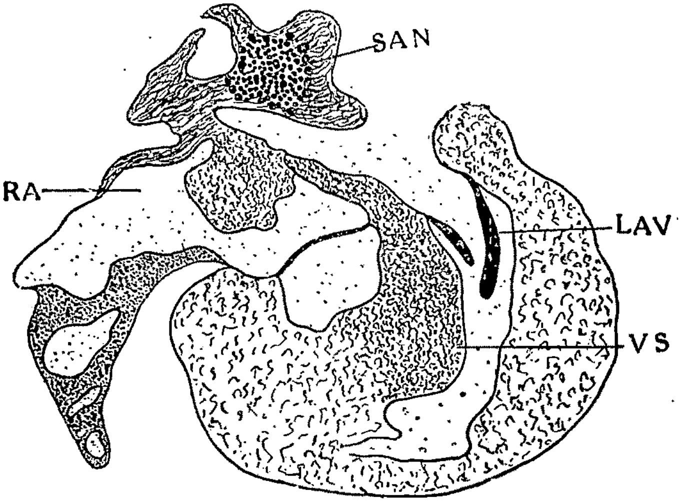

Fig. 1. Diagram to show of the sinuatrial node,

MATERIAL AND METHODS

The hearts of four adult and six new-born rats were used in the present investigation. After being removed from the chloroformed specimens, the material was fixed in Bouin's picroformal. Serial sagittal and coronal sections 6 micra thick were cut from paraffin embedded blocks and stained with either acid fuchsin or by Masson's method (12).

HEART OF ALBINO RATS

Sinuatrial Node.—Consequent to the reduction of the sinus venosus, the sinuatrial node in the heart of albino rats is extensive and well developed. It is present close to the opening of right precaval vein into the right atrium. In transverse and longitudinal sections the node appears as a collection of numerous cells closely packed together and embedded in a loose mesh-work of fibres (fig. 1, 4), which are interlaced with each other. Binucleated and multinucleated cells, stained with acid funchsin, are abundant in the node. The fibres of the node are continous with those of the interatrial septum. Direct transitions of the specialized tissue of the node to ordinary muscle fibres of the interatrial septum, as pointed out by Baird and Robb, have also been observed.

One of the most important features of the heart of albino rats is the occurrence of Purkinje fibres (20) all along the course of the interatrial septum (fig. 5). The fibres are comparatively large but are narrower than those present in the atria or in the ventricular septum. These fibres resemble in their microscopic charcteristics the fibres first described by Purkinje (10) in the heart of sheep and other mammals. The presence of continuous tracts of Purkinje fibres between the sinuatrial and the atrioventricular nodes through the interatrial septum indicate that a special tissue exists in the heart of mammals for conducting the cardiac stimulus to contraction from the sinuatrial junction to the atrioventricular junction.

Atrioventricular Node :—It was easily differentiated from the surrounding tissue, firstly by its circumscribed character and secondly because of its taking a very deep stain with acid fuchsin. The node shows Purkinje fibres and cells inside (fig. 3, 6). The nuclei of cells are large oval bodies, and the

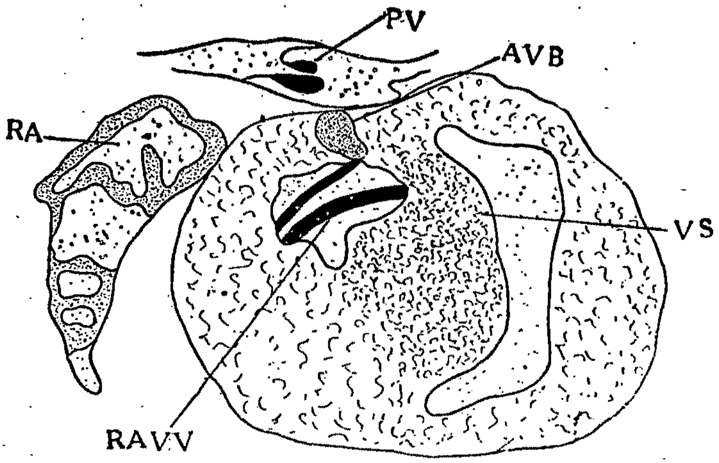

Fig. 2. Diagram to show the position of the Atrioventricular Bundle.

fibres of the node are long and narrow. The atrial fibres sweep into the A. V. node at its cephalic end, while caudally the node is continuous with the fibres of the atrioventricular bundle (8).

Atrioventricular Bundle.—The muscular bundle of His is situated in the cephalic portion of the interventricular septum just beneath the atrioventricular node (Fig. 2). As had been observed already (Prakash, 16) the A. V. bundle is a funnel-shaped structure (Fig. 7) which connects the atrial and ventricular components of the heart of the albino rats. No other connection other than that through the bundle of His was observed between the atria and the ventricles; this confirms the observations of Keith and Flack (10), Kistin (12) and Prakash (16, 19). The existence of one pathway for the conduction of the cardiac stimulus between atria and ventricles shows that if the bundle of His is damaged or cut, the atrial wave of contraction would fail to reach the ventricles and disturbances of rhythm would arise. Moreover the funnel-shaped structure of the bundle controls (16) the movement of the impulse and thus prevents the premature excitation of the ventricles.

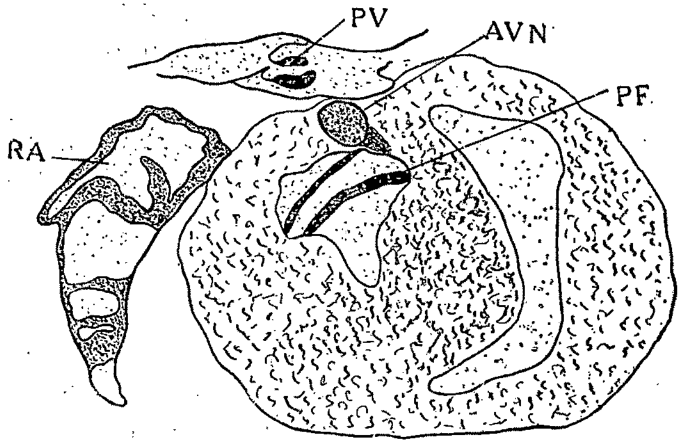

Fig. 3. Diagram to show the position of atrioventricular node.

The bundle of His bifurcates caudally to form a right and a left limb. The two limbs descend on the respective sides of the interventricular septum and serve as muscular bridges to transmit the contraction impulse from the bundle of His to the two ventricles.

DISCUSSION

Contrary to the findings of Glomset and Cross (6), the present study reaffirms the presence of the histologically specialized muscular structures in the form of a sinuatrial node, an atrioventricular node, an atrioventricular bundle, and the right and the left limbs of the bundle of His for initiating and conducting the cardiac rhythm of contraction in mammals. The studies of the most of the investigators show that the contraction impulses are initiated at and conducted by the sinuatrial node to the two atria. The interatrial septum carries these impulses to the atrioventricular node, from where they reach the atrioventricular bundle which conveys them to the two ventricles through its two limbs. The nodal and Purkinje fibres, therefore, form a continuum for the propagation of the rhythmic impulses for the contraction of the cardiac musculature from one portion of the heart to the other.

Walls (23) studied the specialized tissue in the heart of the golden hamster *Cricetus auratus* and pointed out that the S. A. node and the A. V. nodes are not connected directly by any strand of specialized tissue. Baird and Robb (1) state, " No direct tracts of specialized tissue between the S. A. and A.V. nodes were seen in agreement with Keith and Mackenzie (1910) and contrary to the situation in birds (Davies, 1930)". Davies and Francis (4), while reviewing the literature on the conducting system of the vertebrate heart, remarked, "Most observers failed to find any specialized track connecting the two nodes". Recently Copenhaver and Truex (2) also did not find any specialized conduction pathways between the S. A. and A. V. nodes of the heart of the sheep. Thus in the heart of albino rats the occurrence of Purkinje fibres in the interatrial septum to connect the sinuatrial node to the atrioventricular node is noteworthy for mammals. It is also certain that the stimulus originated at the S. A. node would have to go through the Purkinje fibres of the interatrial septum to the A. V. node. The Purkinje fibres may, therefore, be regarded as impulse conducting fibres. Another reason for assigning this function to these fibres is their presence in the S. A. node, A. V. node, and the A. V. bundle, the structures believed to initiate, control and conduct the contraction impulse in the heart of vertebrates.

Kent (11) thought that the idea of only one connection through the bundle of His between the atria and the ventricles in the heart of mammals is erroneous. He observed several muscular atrioventricular connectiosn in the heart of a large number of mammal for conveying the atrial stimulus of contraction to the ventricles. Davies (3) advocated that in the heart of birds both the bundle of His and the multiple atrioventricular connexions of Kent are present in correlation with the rapid rate of heart beat of these animals. Prakash (16) argued that in mammals which show a much slower rate of heart beat the presence of accessory atrioventricular connections for a quick transmission of the contraction impulse from atria to ventricles, would be a disadvantage. In his opinion any atrioventricular bridge in addition to that of the A. V. bundle must carry the wave of contraction from atria to ventricles much earlier than is needed by these slow beating hearts of mammals. In normal hearts with one A. V. connection sufficient time elapses between atrial and ventricular contractions so that the ventricles are fllled with blood completely before they contract. Premature excitation of the ventricles is to be checked to avoid Wolff-Parkinson-White-Syndrome (16).

The results of the present investigation support the myogenic theory of cardiac conduction. The nodal and Purkinje fibres of the heart of birds and mammals are further specializations of the closely woven muscular bundles

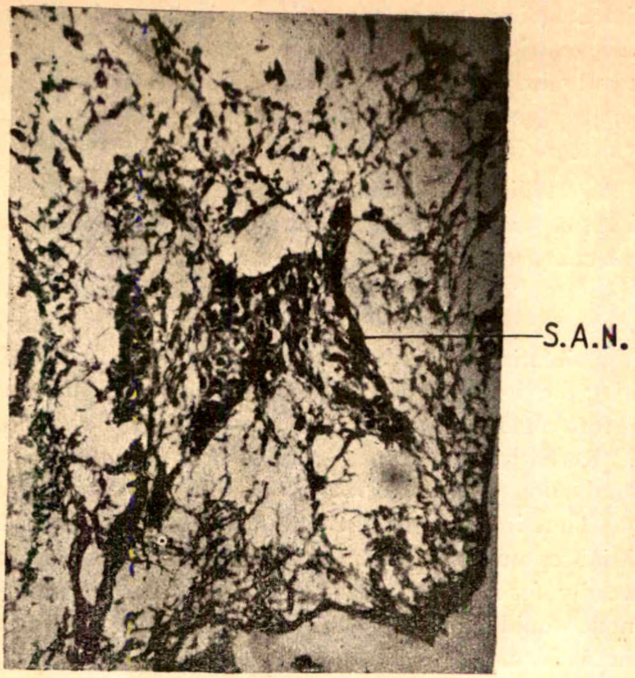

Fig. 4. Photomicrograph of the section through the sinuatrial node.

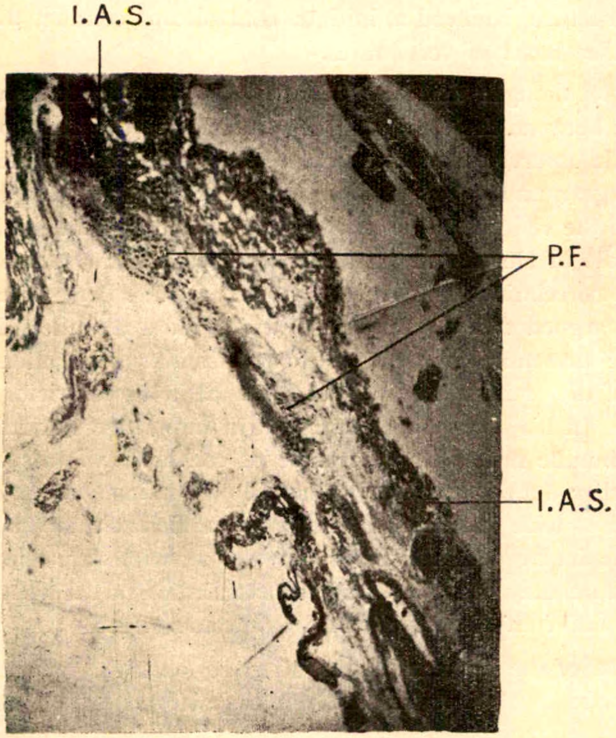

Fig. 5. Photomicrograph of the section showing the presence of Purkinji fibres on the interatrial septum which connect the S. A. node to the A. V. node.

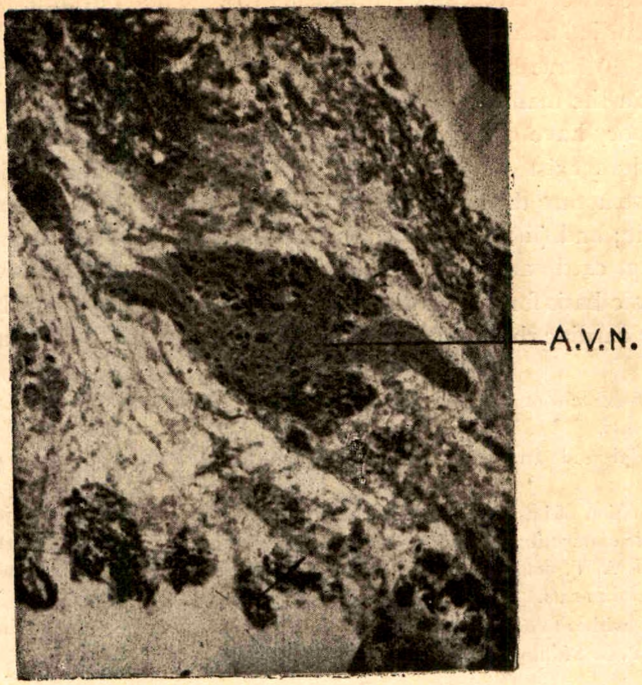

Fig. 6. Photomicrograph of the section through the atrioventricular node.

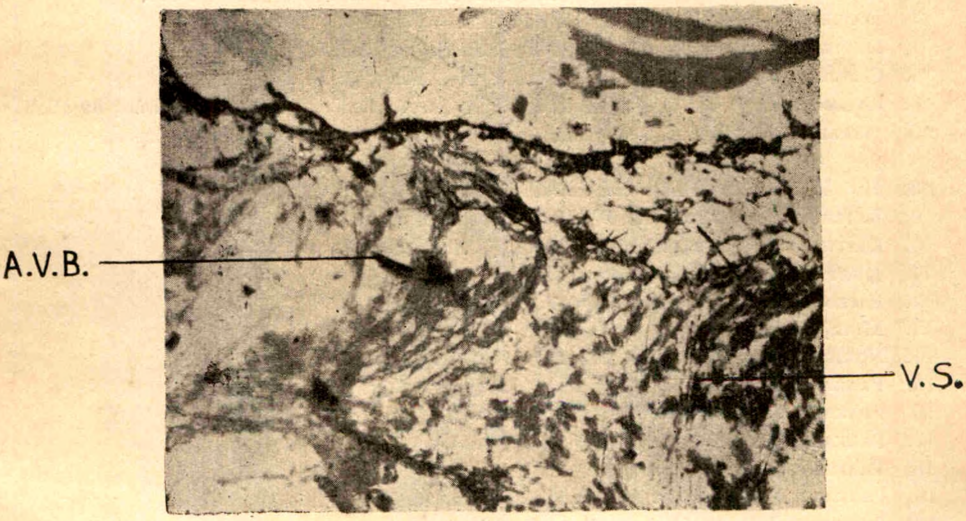

Fig. 7. Photomicrograph of the section through the bunble of His.

of the heart of lower vertebrates (Prakash, 15). The Purkinje fibres which have been regarded as impulse conducting fibres by Davies and Francis (4) and Prakash (19) have been shown by Muir (13) to develop from cardiac muscle fibres in the manner of normal myocardium Even the critics of the myogenic theory have observed in their earlier studies (5) that (i) numerous muscular bridges exist between atria and ventricles, (ii) a definite, easily recognizable structure the node of Tawara A. V. node) is present in sheep, dogs and cattle; and (iii) a distinct ventricular Purkinje system is present in the heart of sheep, cattle and swine. All these studies referred to above provide a sound anatomic basis for advocating the myogenic origin, control and conduction of the cardiac rhythm of contraction in the heart of vertebrates.

SUMMARY

1. The non-existent muscular conducting (connecting) system of Glomset is present in the heart of albino rats.
2. Sinuatrial and atrioventricular nodes are connected through a system of Purkinje fibres.
3. The function of impulse conduction has been assigned to the Purkinje fibres which constitute the sole connecting tissue between the different portions of the heart of mammals.
4. Multiple A. V. connexions of Kent, Davies and Glomset and Glomset were not found in the heart of albino rats.

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ABBREVIATIONS

AVB	Atrioventricular bundle
AVN	Atrioventricular node
IAS	Inter atrial septum
LAV	Left atrioventricular valves
PF	Purkinje fibres
PV	Valves of the pulmonary vein
RA	Right atrium
RAVV	Right atrioventricular valves
VS	Interventricular septum

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